



United States Department of Agriculture
Forest Service
Northern Region



DRAFT

Miller Creek Response Action Engineering Evaluation/Cost Analysis



New World Mining District Response and Restoration Project

MAXIM
TECHNOLOGIES INC.

Draft

**MILLER CREEK RESPONSE ACTION
ENGINEERING EVALUATION/COST ANALYSIS
NEW WORLD MINING DISTRICT
RESPONSE AND RESTORATION PROJECT**

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NEW WORLD MINING DISTRICT
RESPONSE AND RESTORATION PROJECT**

Prepared For:

**USDA Forest Service
Northern Region
Missoula, Montana**

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EXECUTIVE SUMMARY

Maxim Technologies, Inc. (Maxim) prepared this Response Action Engineering Evaluation/Cost Analysis (EE/CA) for the United States Department of Agriculture Forest Service (USDA-FS). This report presents an EE/CA of response alternatives for response and restoration work proposed for mine waste dumps in the Miller Creek drainage source area. These historic mine sites are located in the New World Mining District (District), which is located in Park County, north of Cooke City, Montana. The principal environmental issues at these sites are associated with impacts from historic mining. Human health and environmental issues are related to elevated levels of base-metal contaminants present in mine wastes, disturbed soils, acidic water discharging from mine openings, and contaminants transported in surface water. In addition, ancillary actions are proposed that address natural resource restoration related to roadways as sediment sources to surface waters, and wetlands restoration near the portal of the Glengarry Adit in Fisher Creek. Discussion of proposed District-wide natural resource restoration actions are included in the Miller Creek EE/CA for several reasons, including: 1) Roads associated with historic mining account for a considerable source of metals and sediment in the Miller Creek drainage; 2) The Miller Creek EE/CA is the final EE/CA prepared for the project that will address solid sources of metal contaminants; and 3) The Miller Creek EE/CA is a forum that allows public input and comment on restoration issues.

The District is located at elevations ranging from 2,400 meters (7,900 feet) to over 3,200 meters (10,400 feet) above sea level and is snow-covered for much of the year. The District covers an area of about 100 square kilometers (40 square miles) with historic mining disturbances affecting about 20 hectares (50 acres). The topography of the District is mountainous, with the dominant topographic features created by glacial erosion. The headwaters of Miller Creek are located at or near tree line.

This EE/CA was developed using the “non-time-critical removal” process that is outlined in the *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*, as amended in 1986, and the updated National Oil and Hazardous Substances Pollution Contingency Plan. The USDA-FS has identified the Miller Creek Response Action to address the immediate threat to human health and the environment posed by metal-rich and acidic mine wastes left behind from historic mining and by the contaminated discharge from the underground workings.

Response activities for Miller Creek represent the fourth response action proposed in the New World District during this multi-year project. Previous response actions include the Selective Source Response Action, McLaren Pit Response Action, and the Como/Glengarry Adit/Fisher Creek Response Action.

Existing data from surface water, groundwater, in-stream sediment, and metal-loading to surface waters were reviewed and summarized to plan response activities and evaluate risks to human health and the aquatic environment. In addition, material samples collected from numerous mine waste dumps in Miller Creek were analyzed for heavy metals and acid-base characteristics. Heavy metals associated with these mine waste sources can affect human health through inhalation or ingestion. Metals may also be toxic to plant growth, preventing reestablishment of plant cover on mine waste. Sediment containing heavy metals can erode from mine waste, impacting surrounding land and potentially enter surface water drainages. Water percolating through mine waste can carry dissolved concentrations of heavy metals into groundwater, which, in some areas, discharges to surface water. Percolation of water through sulfide-rich mine waste lowers pH, which promotes solubility of most metals.

A comparison of disturbed soils, waste rock, water, and in-stream sediment data with background concentrations and regulatory standards indicates several metals are contaminants of concern within the Miller Creek source area including aluminum, cadmium, copper, iron, lead, and zinc. Each of these

contaminants has the potential to pose ecological risks. A human health risk evaluation based on *Risk-Based Cleanup Guidelines for Abandoned Mine Sites* (Tetra Tech, 1996) found that lead produces a risk to human health in the Miller Creek drainage. Lead in soil at the Black Warrior dump produces the entire risk to human health for dumps on District Property by both the soil ingestion and dust inhalation pathways. Based on a recreational use scenario, there are no other unacceptable risks to human health. A comparison of metals levels to literature guidelines and state aquatic water quality standards indicates that aluminum, cadmium, copper, iron, lead, and zinc pose risk to organisms in the aquatic environment. In addition, arsenic, cadmium, copper, lead, and zinc may occur at phytotoxic levels in disturbed and metal-rich soils in the Miller Creek waste dumps.

The Miller Creek Source Area contains mine waste deposits as a principal source of sulfide-bearing material that is oxidized to form an acidic, metal-laden leachate, which in turn is mobilized and impacts the quality of surface water and groundwater. While slopes are stable in the small outlying waste because of the length of time they have been in-place, the largely unvegetated mine waste dumps continue to erode and provide contaminated sediment to Miller Creek. Most of the mine waste dumps are located on stable valley side-slopes and only a few occur proximal to surface water in Miller Creek. In addition, dumps are scattered over a wide geographic area and many have difficult access. The Miller Creek Source Area contains 46 small, scattered mine waste piles, 26 of which are located on District Property, and other areas of metal-rich soils and bedrock that provide a pathway for contaminant migration by erosion. Total volume of mine waste on District Property in the Miller Creek Source Area is estimated to be 3,100 cubic meters (4,050 cubic yards) with a combined area of about 1.1 hectares (2.7 acres).

Cleanup goals were identified for metals posing risk at the site. Groundwater and surface water goals are the State of Montana water quality standards. Solid media goals are based on in-stream sediment and soil guidelines found in the literature. After screening a variety of response technologies and process options, several alternatives were developed for detailed analysis. The alternatives were evaluated for effectiveness, implementability, and cost. Table ES-1 lists the Miller Creek Source Area Alternatives.

TABLE ES-1 RESPONSE ACTION ALTERNATIVES FOR THE MILLER CREEK SOURCE AREA New World Mining District Response and Restoration Project Miller Creek Response Action		
Alternative		Response Technology/Process Options
MC-1	No Action	None
MC-2	In-Situ Reclamation of Mine waste Dumps	Grading and compaction of mine waste in-situ, constructing runoff and runoff controls, amendment of the upper 30 cm of the regraded surface with lime, revegetation, and erosion protection.
MC-3	Total Removal and Disposal in an On-Site Repository	Total removal and disposal of waste in the Selective Source repository.

The MC-2 alternative, In-Situ Reclamation of waste dumps, is considered appropriate for the small, scattered sites due to site constraints and access limitations (i.e. most of the sites are on steep slopes that limits access with earth-moving and lime mixing equipment). This alternative involves regrading and compaction of wastes, surface water run-on and runoff controls, shallow lime amendment of the wastes, and revegetation. Alternative MC-3, which involves removal of mine waste present on District Property

to the Selective Source repository site, is also considered appropriate for the Miller Creek Source Area and was developed as a second alternative.

Overall, *In-situ* Reclamation (Alternative MC-2) would be effective in providing suitable soil conditions for revegetation in the short-term and a corresponding reduction in mobility of metal contaminants. However, because site conditions limit the depth of waste treatment, untreated wastes will remain at the sites. Under certain conditions, generally during moderate to extreme weather, untreated wastes could become saturated and release contaminants to the environment. There is also the potential for the treated surface of the waste to reacidify due to capillary rise of acid from underlying untreated wastes, resulting in a reduction in vegetation cover and vigor. Such a mechanism would likely cause the waste dump to revert to pre-treatment conditions. Surface water run-on and runoff controls would be effective in increasing waste dump stability and reducing impacts that result from surface water run-on encountering and transporting waste as sediment or dissolved contaminants to surface water. Maintenance of surface water diversion structures over time would be required.

Alternative MC-3, total removal, is the most effective and most costly of the alternatives considered. This alternative calls for moving the mine wastes to an on-site repository, part of which has been previously constructed. The No Action Alternative does not address surface water impacts, nor does it provide any controls on contaminant migration.

PREFERRED ALTERNATIVE

The preferred alternative for the Miller Creek response action uses a combination of the alternatives discussed. Except for the Black Warrior Dump, there appears to be little major impact from the remaining mine waste dumps located on District Property in Miller Creek. The Black Warrior is the only human health risk identified, and it also contains about 22% of the total mine waste in the Miller Creek drainage on District Property. Elsewhere, environmental risks appear to be associated with mine waste that is in contact with surface water and/or groundwater. This is the case at the Miller Creek Dumps One and Two, which are two dumps located proximal to Miller Creek. Only two other very small dumps sites occur in close proximity to Miller Creek: Miller Creek Dump Four (40 cubic meters, MCSI-00-1) and Lower Miller Creek Dump One (30 cubic meters, MCSI-96-4).

At the Little Daisy Mine, waste rock sits at the mouth of the adit, and discharge from the adit flows through the dump. The flow continues in the subsurface beneath shallow colluvial and talus material below the mine site. This water does not obviously come to surface further downslope. Impacts to surface water from the Little Daisy Mine outflow and waste rock appear to be only minor. This dump is comparable in size to the Black Warrior, containing about 24% of the total waste on District Property in Miller Creek.

Other mine waste dumps and their associated mine sites lie topographically well above the valley bottom, in mostly dry locations, and present no risk to human health and little threat to surface or groundwater quality (except for brief periods during active precipitation or snowmelt). Because of the nominal nature of recognized impacts from remaining dumps in Miller Creek, the preferred alternative for the Miller Creek Source Area is Alternative MC-2 for the four waste dumps located proximal to Miller Creek. These sites include: Miller Creek Dump One (MCSI-99-72), Miller Creek Dump Two (MCSI-96-1), Miller Creek Dump Four (MCSI-00-1), and Lower Miller Creek Dump One (MCSI-96-4). Alternative MC-3, total removal to the Selective Source repository, is selected for the Black Warrior and Little Daisy dumps. Removing these two dumps to the repository eliminates 46% of the total volume of waste rock present in Miller Creek. The No Action Alternative is selected for the remaining dumps on District Property.

In addition to alternatives related to mine waste dumps in the Miller Creek drainage, this EE/CA has examined restoration actions in response to impacts to natural resources related to sediment contamination to surface waters derived from roadways throughout the district. Areas of known and potential acid production and other areas of anomalous metal concentrations in soil and bedrock represent significant sources of contamination, which are exacerbated by surface disturbances such as roads that expose these materials to ongoing erosion both on roadbeds and cut and fill slopes. Many of these roads were historically developed to access the numerous mines and prospects in the District. Sediments derived from roads impact surface water quality as well as aquatic habitat, and reducing sediment derived from roads will improve water quality. Another natural resource restoration issue considered in this EE/CA is the replacement of damaged wetlands in front of the portal of the Glengarry Adit in Fisher Creek. These two items, along with work at the Cumberland Barrel Dump in Miller Creek, are considered ancillary actions to the preferred alternative.

Table ES-2 presents the cost for the preferred alternative. The cost of removal and disposal of the Black Warrior and Little Daisy dumps to the Selective Source repository is estimated to be \$265,000, which includes road upgrades and repository construction costs. Cost of reclaiming the four selected sites in-situ is estimated to be \$63,400. Adding in the ancillary items, engineering evaluation, design, post-removal site control (PRSC), and oversight, the total estimated cost of the preferred alternative is \$1,221,800.

TABLE ES-2 PREFERRED ALTERNATIVE ESTIMATED COST New World Mining District Response and Restoration Project Miller Creek Response Action	
ITEM	ESTIMATED COST
In-situ reclamation (four sites)	\$63,400
Removal of the Black Warrior and Little Daisy Dumps	\$265,400
Natural Resource Restoration	\$667,600
Mobilization/Contingency	\$72,300
Engineering Evaluation/Design/Oversight/PRSC	\$153,100
TOTAL ESTIMATED COST	\$1,221,800

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
ARD	acid rock drainage
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	best available technology
BMP	best management practice
CaCO ₃	calcium carbonate
CBMI	Crown Butte Mines, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
CFR	Code of Federal Regulations
cfs	cubic feet per second
cy	cubic yard
District	New World Mining District
DNRC	Montana Department of Natural Resources and Conservation
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Department of the Interior Environmental Protection Agency
EQ	Ecological Impact Quotient
ER-M	Effect Range- Median
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Tables
HHS	Human Health Standard
HQ	Hazard Quotient
IRIS	EPA's Integrated Risk Information System
L/s	liters per second
MCL	maximum contaminant level
MDEQ	Montana Department of Environmental Quality
MPDES	Montana Pollutant Discharge Elimination System
MWCB	Mine Waste Cleanup Bureau
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm	millimeter
µg/L	micrograms per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFS	National Forest System
ppm	parts per million
PRSC	post-removal site control
RAOs	removal action objectives
RCRA	Resource Conservation and Recovery Act
SAP	sampling and analysis plan
s.u.	standard units
TCLP	Toxicity Characteristics Leaching Procedure
UOS	URS Operating Services
USDA-FS	United States Department of Agriculture Forest Service

I.0 INTRODUCTION

Maxim Technologies, Inc.® (Maxim) developed this Engineering Evaluation/Cost Analysis (EE/CA) for the United States Department of Agriculture Forest Service (USDA-FS). The purpose of this report is to present an engineering evaluation and cost analysis of alternatives for response and restoration work proposed for mine wastes present in dumps and adit seepage located in the Miller Creek drainage of the New World Mining District (District). Response activities will address environmental media affected by historic gold, silver, copper, and lead mining and will be implemented over the life of the project, which is expected to be completed by 2007. The District is located north of Cooke City, Montana, in the Beartooth Mountains (**Figure 1**). Mining disturbances are primarily situated on lands managed or controlled by the USDA-FS.

The primary environmental issues within the District are associated with impacts from historic mining and more recent mineral exploration activities that occurred since prospecting in the area was initiated in about 1869. Human health and environmental issues are related to elevated levels of heavy metal contaminants present in mine waste piles, open pits, acidic water discharging from mine openings, and sediments.

I.1 PURPOSE

The purpose of this EE/CA is to screen, develop, and evaluate potential response alternatives that would be used for cleanup of mining wastes associated with historic mine waste dumps located in the Miller Creek watershed on District Property, which includes all property or interests in property that CBMI relinquished to the United States. Mining impacts present on non-District Property can't be addressed until District Property impacts are alleviated to the satisfaction of the United States. This EE/CA was developed using the "non-time-critical removal" process outlined in the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), as amended in 1986, and the updated National Oil and Hazardous Substances Pollution Contingency Plan (NCP). **Figure 2** displays the non-time critical removal process as it applies to the New World Mining District Response and Restoration Project. A non-time-critical removal action is implemented by the lead agency to respond to "the cleanup or removal of released hazardous substances from the environment... as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment..." (EPA, 1993). In addition, the Miller Creek EE/CA presents proposed District-wide natural resource restoration actions. Following receipt of public comment on the preferred response action alternative identified in this document, the USDA-FS will select a response alternative in an Action Memorandum.

I.2 OBJECTIVES

The geographic area included for study in this EE/CA includes all portions of the Miller Creek watershed from the topographic divide at Daisy and Bull-of-the-Woods passes to the confluence with the Soda Butte Creek immediately east of the town of Cooke City. The drainage basin is bounded by Henderson Mountain to the east and Miller Mountain to the West (**Figure 3**).

Specifically, this EE/CA will focus on two major components that impact the Miller Creek area:

- Mine wastes deposited in dumps on the surface near historic mining operations and mine discharges.
- Erosional problems (mining and road related) that lead to significant sediment and metals loading to Miller Creek.

Observable and measured impacts from these areas include: minor degradation of surface water from both natural and mining related sources, contaminated adit discharges to surface water, seepage from acidic and metal-laden natural soils and mine waste deposits, and erosion. Erosional issues include: the physical transport of mine waste and soil, seasonally heavy sediment loading to surface waters, and physical instability of slopes and stream gradients. The two principal sources of erosional related problems include both areas of existing mine waste and roadways, some of which have been constructed across areas of metals-enriched soils and sulfide-rich bedrock.

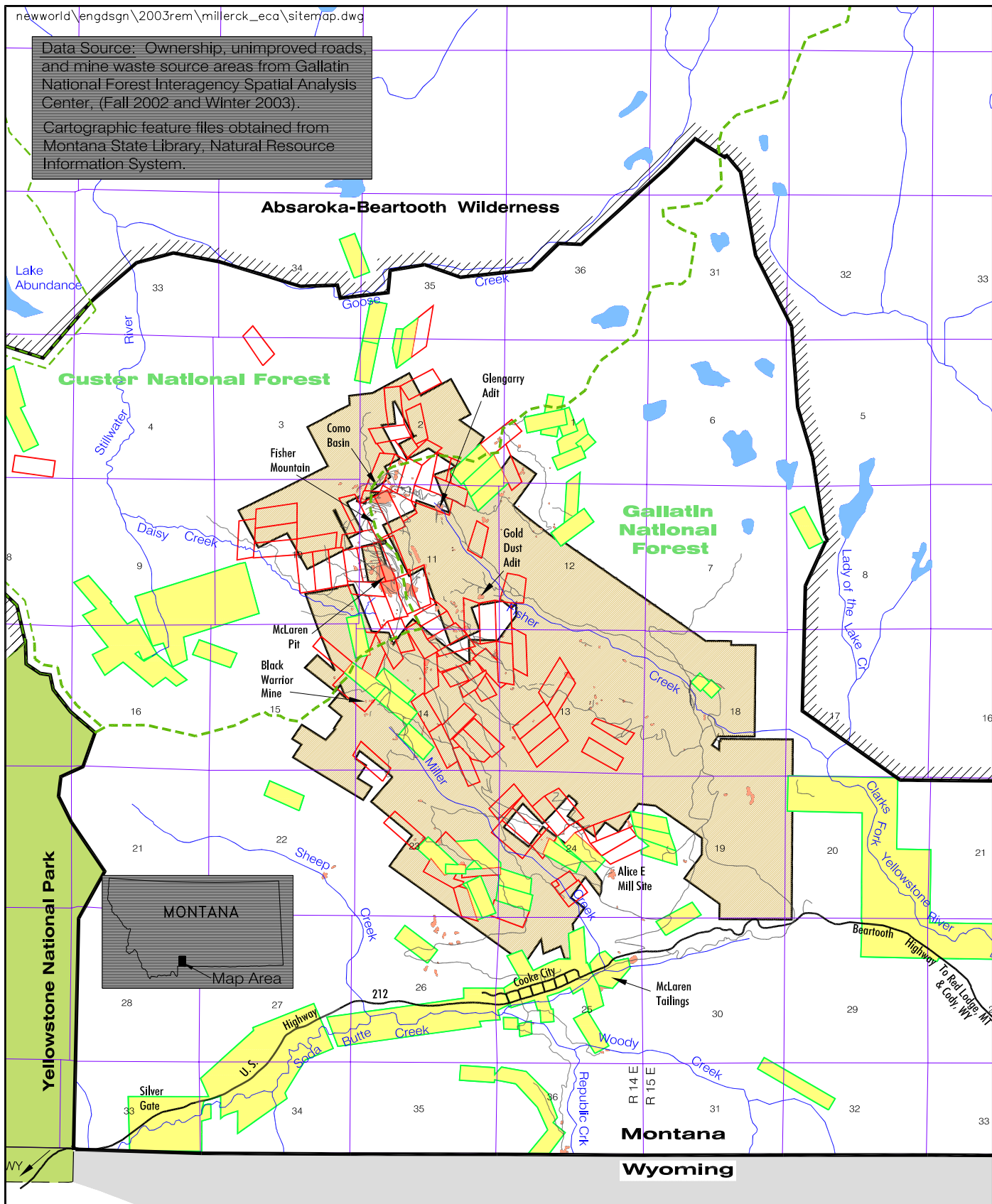
In addition, this EE/CA will address specific natural resource restoration issues that have been identified by a U.S. Forest Service sponsored Natural Resources Working Group. This group is comprised of representatives from various state and federal agencies. Discussion of proposed District-wide natural resource restoration actions are included in the Miller Creek EE/CA for several reasons, including: 1) Roads associated with historic mining account for a considerable source of metals and sediment in the Miller Creek drainage; 2) The Miller Creek EE/CA is the final EE/CA prepared for the project that will address solid sources of metal contaminants; and 3) The Miller Creek EE/CA is a forum that allows public input and comment on restoration issues.

Two principal restoration issues have been identified by the Natural Resources Working Group, the impact of sediment derived from roads throughout the district on surface water quality, and the damage to probable wetlands impacted by historical mining activities located in the Fisher Creek valley immediately southeast of the Glengarry Mine portal. The identified impacts related to these natural resource restoration issues, are described and characterized, restoration actions proposed, and the cost of implementing the actions are estimated in this report. Natural resource restoration activities are carried forward as ancillary actions to the alternatives presented in this report, as these actions are intended to be carried out under all alternatives except for the No Action alternative.

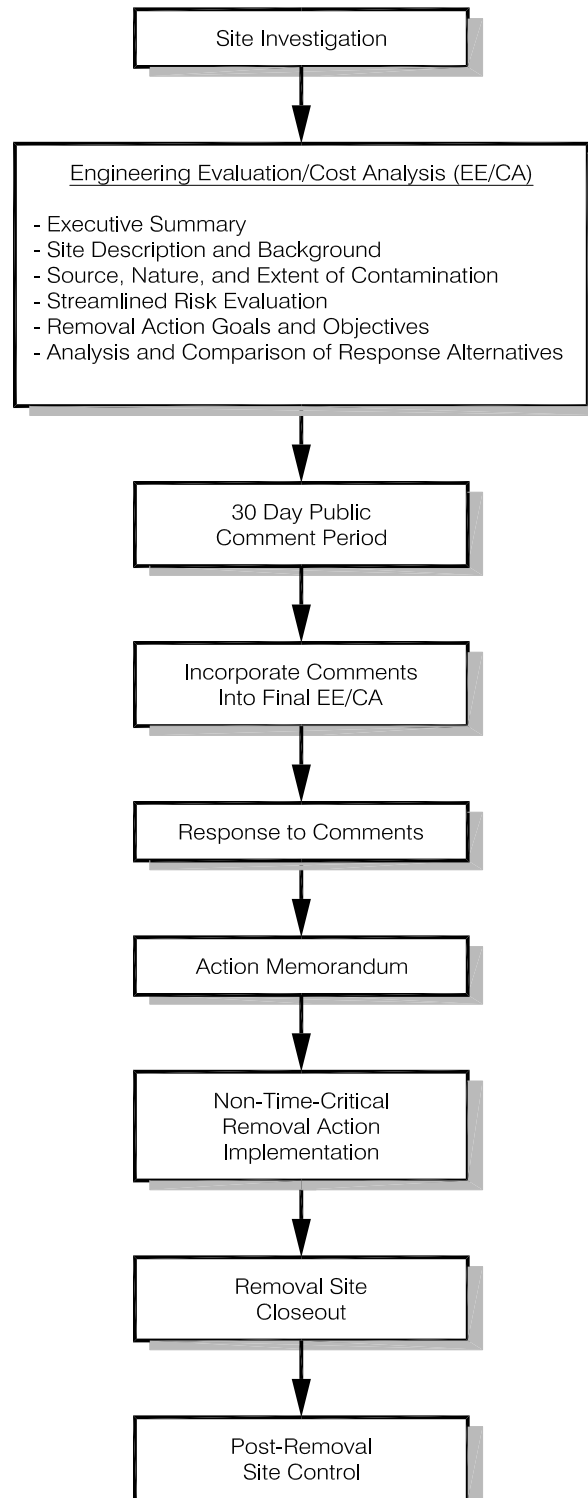
1.3 REPORT ORGANIZATION

This EE/CA is arranged in eight sections. Following this introductory section, the history of the district and descriptions of the site's geologic, hydrologic, and climatic characteristics are presented in Section 2.0. Section 3.0 presents data pertinent to characterizing contaminant sources and pathways of contaminant movement within the Miller Creek drainage basin. In particular contaminated surface water, groundwater, and mine waste sources, and areas of erosion that add to the sediment load in Miller Creek are reviewed. Natural resource restoration issues are also characterized in section 3.0. Section 4.0 summarizes human health and ecologic risks associated with mining wastes and recreational use of the sites. Section 5.0 outlines the response action scope, removal action objectives (RAOs), and goals for the site. The RAOs were developed by the USDA-FS, and goals were identified based on both applicable or relevant and appropriate requirements (ARARs) and representative cleanup guidelines for mine waste sites. In Section 6.0, response action technologies and process options are screened and potentially applicable removal alternatives are developed. Section 7.0 presents a detailed analysis of alternatives using NCP evaluation criteria. Section 8.0 presents a comparative analysis of the alternatives.

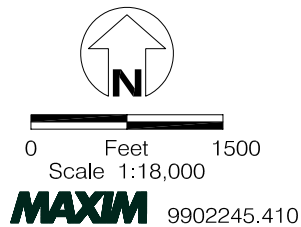
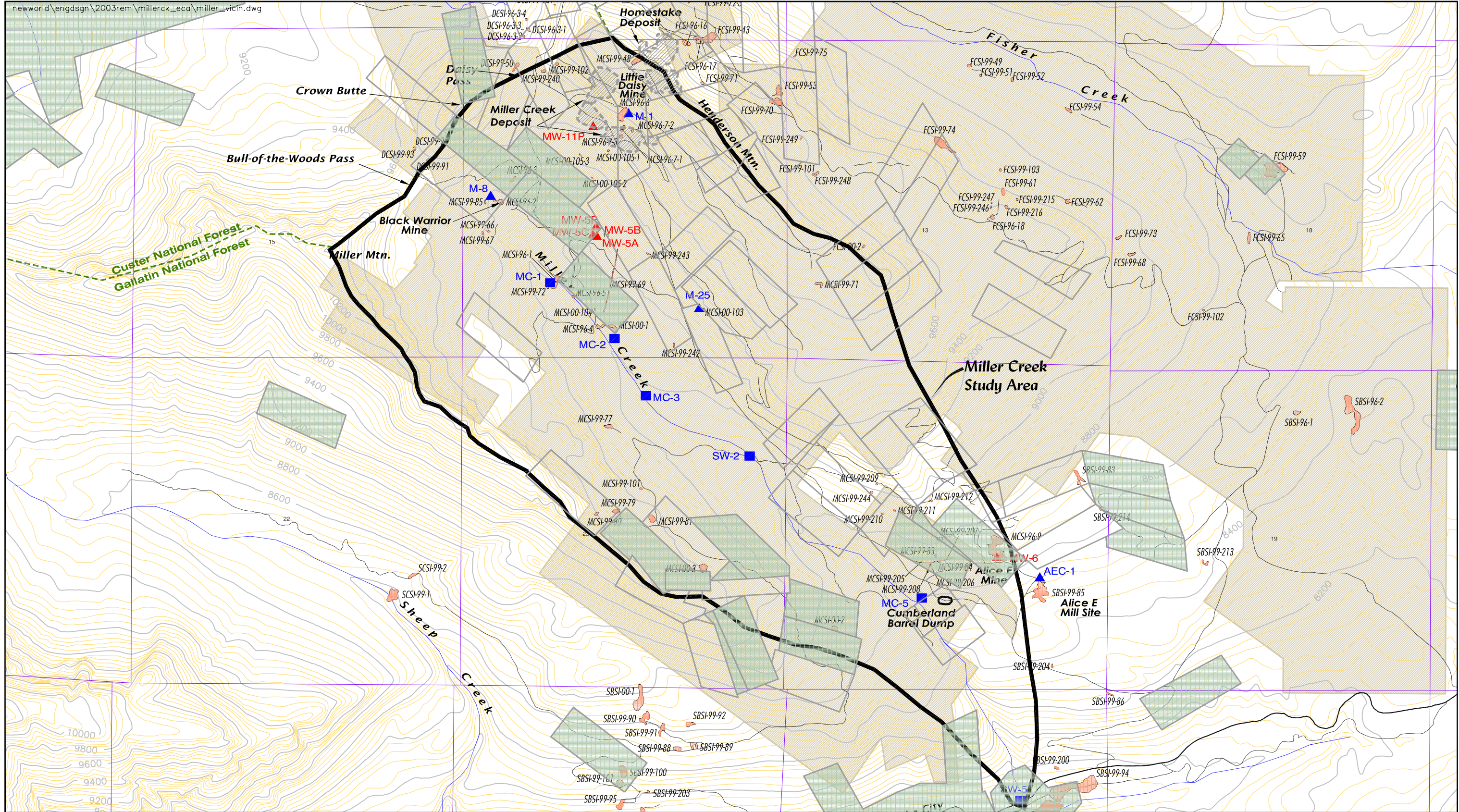
Figures and tables are incorporated into the text of the report. References cited in the document are listed at the end of the text. Appended information includes source area site forms, road rehabilitation costs, and detailed cost estimates for alternatives discussed in Section 7.0.



Project Vicinity Map
New World Mining District
Response and Restoration Project
Cooke City Area, Montana
FIGURE 1



Non-Time-Critical Removal Action Process
New World Mining District
Response and Restoration Project
Cooke City Area, Montana
FIGURE 2



Source: Mine waste source areas from Gallatin National Forest Interagency Spatial Analysis Center (January 2003)
 Topographic data from USGS 7.5 Cooke City Quad
 Contour Interval = 40'
 Ownership and unimproved roads from Gallatin National Forest Interagency Spatial Analysis Center (October 2002)

- Mine Waste Source Area
- Forest Boundary
- Massive Sulfide Deposit
- Surface Water Monitoring Station
- Adit Sampling Station
- Monitoring Well
- Road

- District Property (Patented Claims)
- District Property (Unpatented Claims)
- Private Property

Miller Creek Vicinity Map
 New World Mining District
 Response and Restoration Project
 Cooke City Area, Montana
 FIGURE 3

2.0 SITE DESCRIPTION AND BACKGROUND

The District includes both National Forest System (NFS) land and private land in a historic metal mining area located in the Beartooth Mountains, near Cooke City, Montana (**Figure 1**). This historic mining district contains both mining related and natural features that are pertinent to mine waste cleanup activities. These features include: massive sulfide deposits exposed at the surface; regionally distributed geologic units and deposits enriched in pyrite and chalcopyrite; abandoned mines; hard rock mining wastes; acid discharges from both mine wastes and abandoned mine workings; and natural acid rock drainage (ARD). Human health and environmental issues are related to elevated levels of metals present in various mineralized geologic units, mine wastes, acidic water discharging from mine openings, and contaminated stream sediments.

2.1 PROJECT BACKGROUND

On August 12, 1996, the United States signed a Settlement Agreement (Agreement) with Crown Butte Mining, Inc. (CBMI) to purchase CBMI's interests in the District. This transfer of property to the U.S. government effectively ended CBMI's proposed mine development plans and provided \$22.5 million to cleanup historic mining impacts on certain properties in the District. In June 1998, a Consent Decree (Decree) was signed by all interested parties and was approved by the United States District Court for the District of Montana. The Decree finalized the terms of the Agreement and made available the funds that are being used for mine cleanup. Monies available for cleanup are to be first spent on District Property (**Figure 1**). If funds are available after District Property is cleaned up to the satisfaction of the United States, other mining disturbances in the District may be addressed. In addition, in a Memorandum of Understanding (MOU) between USDA, United States Environmental Protection Agency (EPA), and the Department of the Interior, an amount not to exceed \$2.5 million was specifically identified that might be used for restoration actions related to natural resources impacted by mining activities (MOU, 1998).

Mitigation of impacts from acid-generating historic mining wastes has been an objective of investigators in the District since the 1970s. One of the first to investigate revegetation in the District was the USDA-FS Intermountain Research Station (Brown et al., 1995; 1996). This research has focused on reclaiming high elevation mine disturbances, in acidic, metal-laden soils with emphasis on specific issues associated with species selection, fertilization, planting season, organic amendments, acid soil amendments, and surface soil treatments. Some reclamation work was completed voluntarily by CBMI on District Property from 1991 to 1993, including work to reclaim the historic McLaren open pit mine disturbance and areas disturbed by exploration activity in the Como Basin. Reclamation activities in the Miller Creek area consisted of surface recontouring of exploration access roads and drill pads principally associated with exploration drilling of the Miller Creek and Homestake deposits, but also included other small outlying exploration drilling target areas. Fertilizing and seeding these disturbances with native grasses followed the recontouring.

In 1995, the (EPA) began a site investigation after the initial announcement of the property transfer from CBMI. The EPA investigation involved installing monitoring wells, surface water sampling, groundwater monitoring, and completing a groundwater tracer study. The results of these studies were published in two technical reports (URS, 1996; 1998) and included a description of the following: a review of all previous surface water and groundwater data collected by the Montana Department of Natural Resources and Conservation, USDA-FS, CBMI, EPA, and URS; an evaluation of the data collected during the 1996, 1997 and 1998 field season; and an overall evaluation of the complete data set with respect to adequacy for restoration and reclamation of historic abandoned mines.

The USDA-FS assisted CBMI in October 1998 in completing and submitting a Support Document and Implementation Plan to support the CBMI petition for temporary modification of water quality standards. The Support Document and Implementation Plan were submitted to the State of Montana Board of Environmental Review on January 22, 1999, and a rule was approved on June 4, 1999. The petition for temporary standards was necessary to temporarily modify surface water quality standards for Daisy and Fisher Creeks and a headwater portion of the Stillwater River so that improvements to water quality may be achieved by implementation of the response and restoration project.

Major work completed during the first three years of cleanup activity initiated by the USDA-FS was associated with the Selective Source Response Action (Maxim, 2001a). Construction activities associated with this response action, were completed in 2002, and involved removing approximately 25,000 cubic meters (32,000 cubic yards) of mine waste and mill tailings from seven mine waste areas, disposing of these wastes in an engineered repository, and revegetating about 1.9 hectares (4.6 acres) of the former waste areas. The waste areas cleaned up and the volume of waste permanently disposed represent about 9% of the mining impacted area and about 8% of the waste located on District Property. Mine wastes included in this first cleanup action were the Tredennic, Spalding, and Small Como dumps, and the Rommel and Soda Butte tailings.

The second response action implemented by the USDA-FS in the District was the McLaren Pit Response Action (Maxim, 2001b). Construction activities were initiated in 2002 and are scheduled for completion in 2003. These activities include consolidation of waste rock dumps from the Daisy Creek headwaters area into the McLaren Pit, and capping of the consolidated wastes with an impermeable cap. The scope of the McLaren Pit Response Action is limited to reducing or eliminating uncontrolled releases of metals from mine waste dumps in the Daisy Creek headwaters. The waste dumps slated for consolidation into the pit are the McLaren Pit spoils (wastes located below the county road and west of the pit) and the multicolor dump. Approximately 18,350 cubic meters (24,000 cubic yards) of waste rock are contained in the dumps, which cover about 1.4 hectares (3.5 acres) of disturbance. An additional 137,600 cubic meters (180,000 cubic yards) of waste located in the former McLaren Pit will be covered with the impermeable cap. These three waste source areas account for about 67% of the District's total mine waste volume located on NFS lands.

The third response action that will be implemented by the USDA-FS is the Como Basin/Glengarry Adit/Fisher Creek Response Action (Maxim, 2002). Three separate source areas were evaluated in this study and include: the Como Basin Source Area, the Fisher Creek Source Area, and the Glengarry Adit Source Area. The Como Basin and Fisher Creek source areas are similar in that they both contain contaminated soils and/or mine waste rock deposits as a principal source of sulfide-bearing material that is oxidized to form an acid-rich, metal-laden leachate, which is in turn mobilized and impacts the quality of surface and groundwater. These two areas differ in scale in that the Como Basin Source Area is a large area (2.23 hectares; 5.5 acres), whereas the Fisher Creek Source Area contains a number of small scattered waste rock piles in the upper Fisher Creek drainage and other small, but locally severe erosional problems. The preferred alternative for the Como Basin Source Area uses a composite cover system (geomembrane liner overlain by amended soil) to confine and reduce the mobility of contaminants present in soils in the basin. The preferred alternative for the Fisher Creek Source Area is the use of surface controls (regarding, drainage control, shallow soil lime amendment, and revegetation) for select waste rock dumps except the Glengarry and Gold Dust dumps, which are proposed for removal to the Selective Source repository. The preferred alternatives for the Como Basin and Fisher Creek source areas are expected to be constructed in 2005. The Glengarry Adit Source Area, where contaminated inflows into underground workings enter the mine and flow through the mine workings, and then discharge contaminated water into Fisher Creek, will be cleaned up beginning in 2003 by eliminating or minimizing contaminated inflows and outflows from the mine.

2.2 SITE LOCATION AND DESCRIPTION

The District falls within the boundaries of the Gallatin and Custer National Forests and lies adjacent to Yellowstone National Park's northeastern-most corner. The Absaroka-Beartooth Wilderness Area bounds the District to the north and east. To the south of the District is the Montana-Wyoming state line and NFS lands administered by the Shoshone National Forest. The District lies entirely within Park County, Montana.

The communities of Cooke City and Silver Gate, Montana are the only population centers near the District. The neighboring communities of Mammoth, Wyoming and Gardiner, Montana are located about 80 kilometers (km) (50 miles) to the west. Red Lodge, Montana is about 105 km (65 miles) to the northeast via the Beartooth Highway (US Highway 212), and Cody, Wyoming is located 100 km (60 miles) to the southeast via the Chief Joseph Scenic Byway, or Sunlight Basin road.

The District is located at elevations ranging from 2,400 meters (7,900 feet) to over 3,200 meters (10,400 feet) above mean sea level; the site is snow-covered for much of the year. Only one route of travel is open on a year-round basis to the District, the highway between Mammoth and Cooke City. The Sunlight Basin road allows access to the District from northwestern Wyoming during the spring, summer and fall but only allows access to within a few miles of the District in winter. The Beartooth Highway is closed during winter, as is Highway 212 from Cooke City eastward to Pilot Creek near the Montana-Wyoming state line.

The District covers an area of about 100 square kilometers (40 square miles). Historic mining disturbances affect about 20 hectares (50 acres). The topography of the District is mountainous, with the dominant topographic features created by glacial erosion and glacial deposits. The stream valleys are U-shaped, broad, and underlain at shallow depths by bedrock, while the ridges are steep, rock covered, and narrow. Much of the District is located at or near tree line, especially in the vicinity of Fisher Mountain, where the major historic mining disturbances are located.

The District is situated at the headwaters of three tributaries of the Yellowstone River: the Clark's Fork of the Yellowstone, the Stillwater, and the Lamar. Headwaters tributaries that feed these three branches of the Yellowstone are named, respectively, Fisher Creek, Daisy Creek and Miller Creek. The other major named tributary streams in the District include Goose, Sheep, Lady of the Lake, Republic, Woody, and Soda Butte creeks (**Figure 1**). Miller Creek, the drainage basin that is the subject of this report, flows south from Daisy and Bull-of-the-Woods passes to its confluence with Soda Butte Creek just east of the town of Cooke City (**Figure 1**). From there, Soda Butte Creek flows westward to a confluence with the Lamar River, in the Lamar Valley of Yellowstone National Park, which in turn flows westward to its confluence with the Yellowstone River, also within Yellowstone National Park.

2.3 MINING HISTORY

Mining exploration in the District began in 1864 when prospectors from the mining camp of Virginia City explored the area. The earliest placer and lode deposits were prospected in 1869. In 1876, the Eastern Montana Mining and Smelting Company constructed a smelter in the Cooke City area. In 1883 the Republic Smelter was built for the reduction of silver-lead ore. It was located on the western end of town, on the south side of Soda Butte Creek. During these early years of development, the District was a part of the Crow Reservation. When the U.S. government withdrew this land from the reservation and put it into public ownership in 1882, interest in mining in the District heightened with the filing of 1,450 claims (Wolle, 1963).

Mining activity fluctuated greatly between 1882 and the late 1920s, hampered primarily by the lack of a railroad to ship ore and supplies, and the long and severe winters. Numerous smelters were built, although most only operated for a few years at a time. A portable smelter was reported to have been in operation in the Miller Creek drainage in the late 1880's. Gold was mined on Henderson Mountain beginning in 1888. During 1893 and 1894, gold was mined from underground workings and an open pit on Henderson Mountain (Reed, 1950). A road over Lulu Pass was built during 1905-1906 to reach a copper lode in the area of Goose Lake (URS, 1996).

A number of small mining companies operated underground mines that were developed in the early 1920s. The Glengarry Mining Company operated a flotation mill in the upper Fisher Creek drainage in the 1920s to process copper-gold ores from the Spaulding Tunnels developed in a north-south fault structure (Crown Butte Fault) on the south side of Scotch Bonnet Mountain (Reed, 1950). Later, in the mid-1920's, the Glengarry Mining Company drove an adit, the Glengarry Adit (**Figure 1**), from the base of Lulu Pass in the Fisher Creek drainage to intercept ore at depth along the mineralized structure of the Spaulding Tunnels. No ore-grade mineralization was encountered in this adit (Lovering, 1929). Prior to 1934, a southwest heading was driven from an underground location in the Glengarry Adit beneath the Como Basin, and a raise driven to surface in massive sulfide mineralization of the Como stratabound replacement deposit near Lulu Pass.

The Tredennick Mines were operated by the Tredennick Development Company on claims located on the southeast flank of Scotch Bonnet Mountain. The workings consist of three principal adits with about 419 meters (1,375 feet) of combined workings. The middle adit intercepted a narrow zone of copper-gold mineralization at the contact with Precambrian basement and the gabbro of the Scotch Bonnet intrusive complex. No significant production was recorded from any of the Tredennick workings (Lovering, 1929).

The Gold Dust Adit is located on the southwest side of the Fisher Creek Valley, near the break in slope forming the flank of Henderson Mountain (**Figure 1**). The adit was driven by Western Smelting and Power Company between 1920 and 1925 and drifts to the southwest for about 700 meters (2,300 feet). No production is recorded from the adit. By 1925, the estimated production of the District was \$215,000 in gold, silver, copper, and lead (Wolle, 1963).

Three mines were important in the early mining history of the Miller Creek area: the Little Daisy Mine (also known as the Daisy Mine), the Black Warrior Mine, and Alice E Mine. In addition to these three mines, there are several small underground mines that were operated on the west side of Miller Creek, on the mid- to lower-slopes of Miller Mountain (**Figure 3**). The Little Daisy Mine is located on the northwestern slope of Henderson Mountain southeast of Daisy Pass. Western Smelting and Power operated the mine intermittently from 1888 to about 1918. The Little Daisy Mine has approximately 2,385 feet of workings (Lovering, 1929) with portals on both the southwest and northeast flanks (Homestake Adit) of Henderson Mountain (**Figure 3**). The Little Daisy Mine produced gold and copper ore from sulfide and oxide replacement mineralization in blocks of Pilgrim Limestone caught up in the Homestake Stock and the upper portion of the Homestake Breccia Pipe.

The Black Warrior Mine (**Figure 3**) lies southeast of Bull-of-the-Woods Pass, near the headwaters of Miller Creek. It consists of an underground adit about 130 meters (425 feet) in length and a 24-meter high (80-foot) raise to surface. The adit was driven to the north-northeast along fracture-controlled lead-zinc-silver mineralization in the Pilgrim Limestone along what may be a splay of the Crown Butte Fault zone.

The Alice E Mine (**Figure 3**) is located on the southwestern flank of Henderson Mountain. The mine was operated in the mid-1890s as an open-pit operation that mined oxidized gold from fracture-

controlled mineralization in the Flathead Formation (sandstone/quartzite). Some gold-bearing pyritic ore is exposed in these workings and contained in the waste rock; however, because the Alice E Mine recovered gold using cyanide it was not effective in treating sulfide-rich ores. The Alice E Mine proper is located on private property, although the mill site that contains both tailings and waste rock is located on NFS land (non-District Property).

In 1933, a gold-copper-silver mining operation, the McLaren Mine, was developed on the west side of Fisher Mountain. Milling of the ore produced from this mine was done in Cooke City at the Cooke City Mill. The Cooke City Mill was a gravity/flotation mill that produced a concentrate that was then shipped through Yellowstone National Park to a railhead in Gardiner, Montana. With the destruction of the McLaren Mill by fire in 1953, mining in the District ceased. Total metal production from the New World District is 62,311 ounces of gold; 692,386 ounces of silver; 1,963,800 pounds of copper; 3,242,615 pounds of lead; and 920,200 pounds of zinc (Lovering, 1929; Reed, 1950; Eyrich, 1969; Wolle, 1963; Krohn and Weist, 1977). Nearly all of the gold and copper came from the McLaren Mine. Most of the lead, zinc, and a large portion of the silver came from mines in the Republic District south of Cooke City.

Extensive exploration of the area by a number of major mining companies for sediment hosted massive sulfide and porphyry copper and molybdenum deposit, continued from 1974 until 1996, with CBMI as the last major company to hold an interest in the District. CBMI executed exploratory drilling programs for stratabound replacement and breccia pipe deposits containing gold, copper and silver mineralization in the District from 1987 to 1993. This exploration work produced new subsurface deposit discoveries and lead to extensive drilling in the Miller Creek and Homestake deposit areas located under the north end of Henderson Mountain in the upper Miller Creek drainage.

2.4 DISTRICT GEOLOGY

The geology and mineral deposits of the District were mapped and described by Lovering (1929) and the geology of the Cooke City Quadrangle was mapped by Elliott (1979). Reed (1950) described many of the mines and summarized production from the District. Additional information on alteration and mineralization in the District is available from Eyrich (1969), Johnson (1991), Johnson and Meinert (1994), and guidebook articles by Johnson (1992) and Elliot, et. al., (1992).

Precambrian basement rocks, predominantly granitic gneisses, are exposed over much of the northern and eastern part of the New World District, including the valley floor along lower Fisher Creek and scattered outcrops on the southern flank of Henderson Mountain (**Figure 4**). Paleozoic sedimentary rocks consisting of sandstone, siltstone, shale, limestone and dolomite unconformably overlie these basement rocks and occur on the north and west flanks of Fisher Mountain, on the southwest flank of Sheep Mountain, and outcrop extensively in the Miller Creek area along the flanks of Henderson Mountain, Miller Mountain, and Crown Butte. These sedimentary rocks generally dip gently to the southwest and are intruded by Tertiary (Eocene) felsic calc-alkaline stocks, laccoliths, sills and dikes. There are four principle plutons in the District. From north to south these are: Scotch Bonnet Diorite, Fisher Mountain Intrusive Complex, Homestake Stock, and the Henderson Mountain Stock. The Fisher Mountain and Homestake Intrusive complexes (**Figures 4**) exhibit concentrically zoned, porphyry-style alteration characterized by quartz-sericite-pyrite-chalcopyrite alteration assemblages. Both of these intrusive complexes were explored in the 1960s-1980s for porphyry copper and porphyry molybdenum deposits.

The Miller Creek drainage occurs along the southwest flank of Henderson Mountain, which is cored by the Homestake and Henderson Mountain Stocks. The location of the valley is controlled by Pleistocene

(glacial) and recent erosion along the Crown Butte Fault that crosses Crown Butte and Daisy Pass and extends southward along the Miller Creek valley axis (**Figure 4**).

The gold-copper-silver deposits in the District are of three principal types: 1) tabular, stratabound, skarn and massive sulfide replacement deposits hosted by the Meagher Limestone Formation of Cambrian-age (i.e., Como, McLaren and Miller Creek deposits); 2) replacement (i.e., Fisher Mountain deposit) and vein-type mineralization along high angle faults and fractures (i.e., Little Daisy Mine, Spaulding and Tredennick deposits); and 3) sulfide and oxide replacement deposits of limestone clasts in diatreme and intrusion breccias (i.e., Fisher Mountain Intrusive Complex and Homestake Breccia Pipe deposit). Late stage vein and replacement deposits of lead, zinc and silver that occur more peripheral to the district, some of which occur in Miller Creek (Black Warrior Mine, and some Miller Mountain deposits) are also genetically related to these two stocks.

2.5 MINERALIZATION IN THE MILLER CREEK AREA

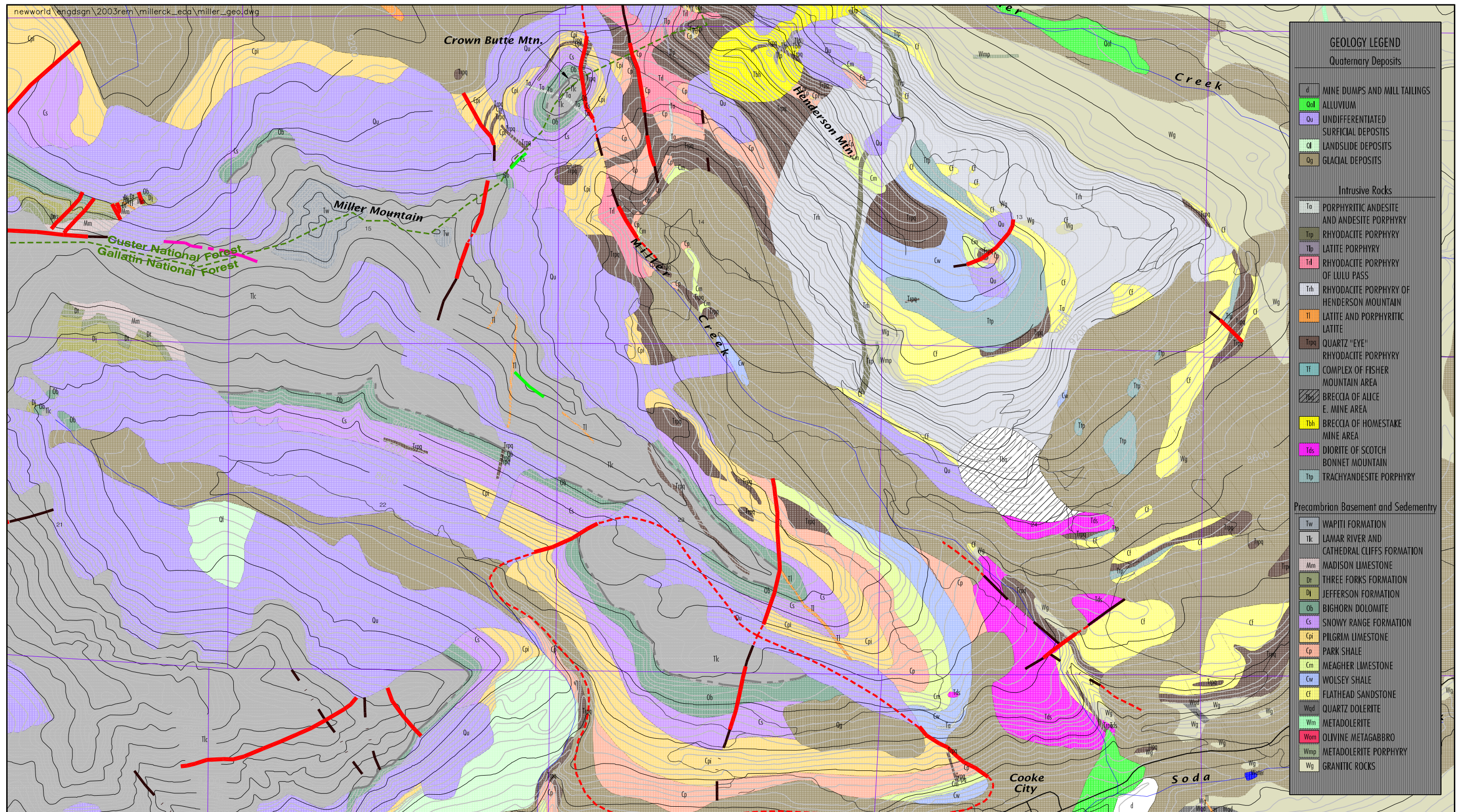
Mineralization in the Miller Creek area is spatially, temporally and genetically related to the emplacement and alteration of the Fisher Mountain Intrusive Complex, and the Homestake and Henderson Mountain stocks (**Figure 4**). This mineralization consists of small-scale historical mining operations (both open pit and underground), and recently discovered subsurface deposits (**Figure 3**). In addition, recent exploration activities have identified large areas of mineralization and alteration containing anomalous metal enrichment in intrusive country rock and overlying soils on the southwest flank of Henderson Mountain.

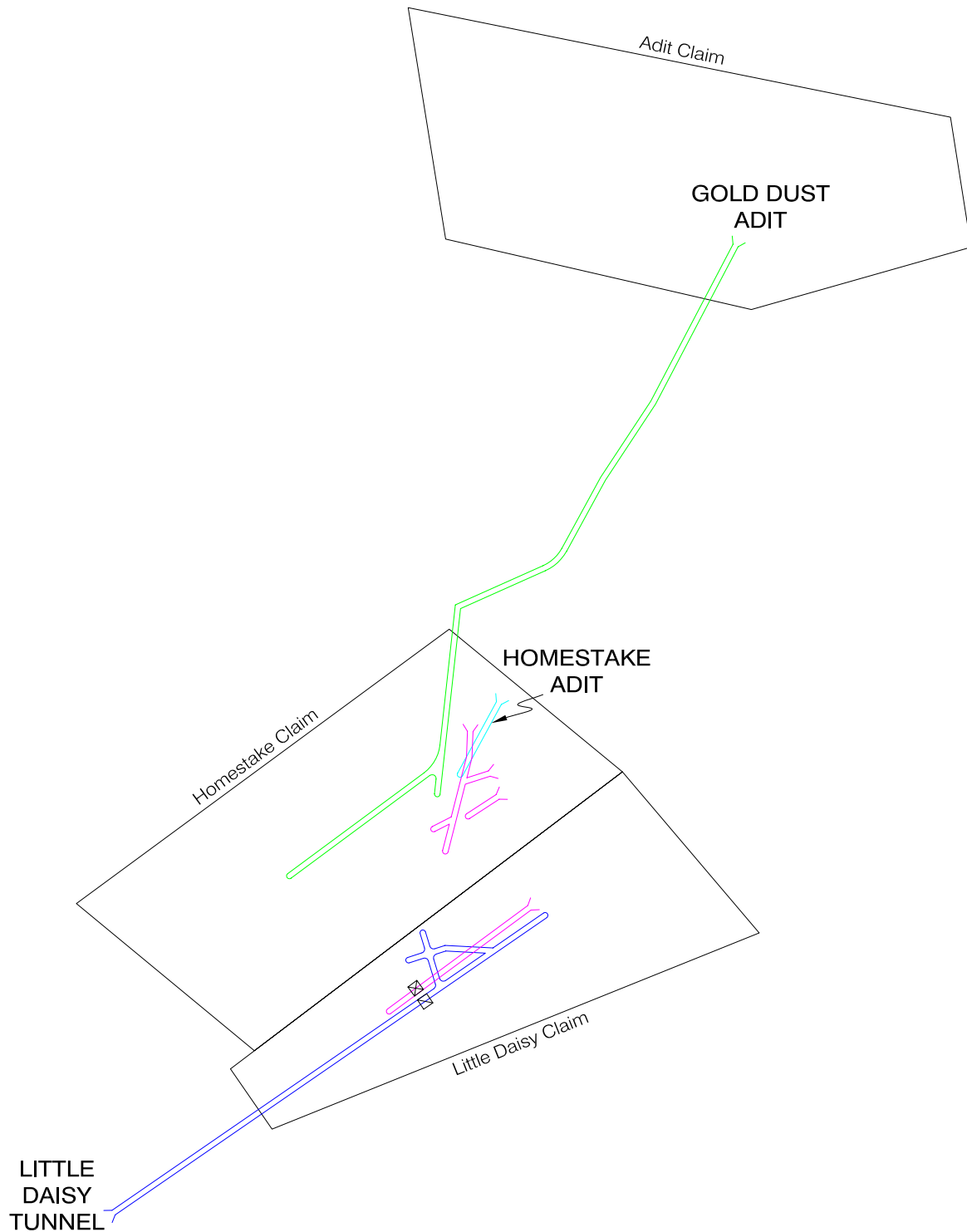
2.5.1 Description and Mineralization of Historically Operated Mines

Historically operated mines in the Miller Creek area include the Daisy, Black Warrior, Alice E, and various small underground mines developed on the eastern flank of Miller Mountain, west of Miller Creek (**Figure 3**). There are also numerous prospect pits and caved adits throughout the valley.

2.5.1.1 LITTLE DAISY MINE:

The Little Daisy Mine is located on the northwestern slope of Henderson Mountain southeast of Daisy Pass at an elevation of about 3,000 meters (9,840 feet) (**Figure 3**). The ruins of a stamp mill (only the foundation remains, the stamp mill was moved to Cooke City), boarding house, stable, and two cabins are located at the mine site just below the portal between the adit and the Daisy Pass road. The mill-site encompasses an area of about 0.07 hectares (0.17 acres) and contains about 240 cubic meters (314 cubic yards) of waste in three small dumps. The Little Daisy Mine has approximately 726 meters (2,385 feet) of workings (Lovering, 1929) with portals on both the southwest and northeast flanks of Henderson Mountain (**Figure 5**). The longer of the two adits is collared just above the old stamp mill site. Its trend is ENE and the workings are approximately 427 meters (1,400 feet), in length. Only about 366 meters (1,200 feet) of these workings were accessible in the early 1920's (Lovering, 1929). This adit is connected by a raise (approximately 60 meters, 200 feet in height) that connects with a shorter adit that collars on the northeast flank of Henderson Mountain (elevation 3,036 meters, 9,960 feet). This adit was driven to the west-southwest, parallel to and slightly northwest of the main Daisy adit and is about 152 meters (500 feet) in length. The top of the raise is about 122 meters (400 feet) in from the portal of this adit. The portal on the Daisy Creek side has been backfilled and access blocked with mine wastes (**Figure 6**). There is a small dump on the scree slope below the portal containing about 535 cubic meters (700 cubic yards) of waste rock (**Figure 7**) and the mine portal discharges about 7.6 liters per minute (2 gallons per minute) of water. The area encompassed by the mine site and waste rock dump is about 0.2 hectares (about 0.5 acres).





(after Lovering, 1929)

Map of Underground Workings in the Little Daisy Adit
Homestake Adit and Gold Dust Adit Mine Areas

New World Mining District
Response and Restoration Project

FIGURE 5



0 Feet 400

MAXIM
TECHNOLOGIES INC® 9902245.233

☒ Raise or Winze
☒ Top
☒ Bottom



Figure 6. The portal of the Little Daisy Mine, located on the west side of Henderson Mountain has been backfilled and access blocked with mine wastes (note seepage) (looking east).

Mineralization consists of blocks of Park Shale and Pilgrim Limestone caught up in an intrusive matrix (quartz monzonite of the Homestake Stock) to form an intrusion breccia. The sedimentary blocks have been skarn-altered and replaced by assemblages of garnet, epidote, magnetite, pyrite and chalcopyrite. Although gold was recovered in the stamp mill at the Daisy mill site, Lovering (1929) suggests that most of the ore's value must have been in copper.

Drilling by CBMI between 1990 and 1993 identified ore grade mineralization in the Homestake Breccia Pipe (a phreatic explosion vent to the surface) that indicated the developers of Western Smelting and Power were indeed exploring in the right area. The Daisy Adit penetrates Henderson Mountain about 18 meters (60 feet) above the elevation of ore-grade mineralization of the Homestake Breccia Pipe.



Figure 7. Little Daisy Mine waste rock dump (MCSI-96-6) and millsite. A small waste rock dump occurs on the scree slope below the portal of the Little Daisy Mine containing about 680 cubic meters of waste rock. A portion of the Daisy mill site and two small dumps (MCSI-96-7-1 and MCSI-96-7-2) can be seen in the foreground (looking northeast).

2.5.1.2 BLACK WARRIOR MINE:

The Black Warrior Mine lies near the headwaters of Miller Creek (**Figure 3**). It consists of an underground adit about 130 meters (425 feet) in length and a 25-meter (80-foot) raise to surface. The collar of the raise to surface occurs at an elevation of about 2,893 meters (9,490 feet) and lies just to the southeast of Bull-of-the-Woods Pass. The adit was driven to the north-northeast along a high angle fracture or fault that is likely a splay of the Crown Butte Fault zone. Both vein and replacement type deposits of lead-zinc-silver mineralization occur in the Pilgrim Limestone host. The area disturbed at the Black Warrior portal area is about 0.07 hectares (0.17 acres) and includes a small ore load-out structure. There is a small dump (610 cubic meters, 800 cubic yards) at the collapsed mine portal, which has been closed with backfilled mine wastes (**Figure 8**). A small volume of water, ranging from about 0.34 liters per minute (0.09 gallons per minute) to as much as 4.2 liters per minute (1.1 gallons per minute), exits the portal. The shaft was closed by CBMI for safety reasons by backfilling with waste rock and dolomite. A soil cover was placed over the disturbed portion of the shaft site and the site was seeded and fertilized. Another shallow inclined shaft occurs to the northwest at Bull-of-the-Woods Pass at an elevation of 2,891 meters (9,780 feet) (DCSI-99-91 on **Figure 3**).



Figure 8. Photograph of the Black Warrior portal area and waste rock dump (MCSI-96-2).

2.5.1.3 ALICE E MINE.

The Alice E Mine (**Figure 3**) is a non-District Property located on the southwestern flank of Henderson Mountain on privately owned land. The mine was operated in the mid-1890s as an open-pit operation that mined oxidized gold from stockwork fracture controlled mineralization in the Flathead Formation (sandstone/quartzite). Shallow underground mining in various adits and stopes are also present in the mine area and have locally caved to surface. Some gold-bearing pyritic ore is exposed in these workings and contained in the waste rock. Since this mine site is located on private land, it is not considered further in this report.

2.5.1.4 THE ALICE E MILLSITE.

The Alice E Millsite is a non-District Property located on NFS land (Figure 3). The millsite appears to drain into Soda Butte Creek rather than Miller Creek and is designated as SBSI-99-85. The millsite used a cyanide leach process to recover gold, but this method of gold extraction was not suited to treating sulfide-rich ores. Apparently no attempt was ever made to process the sulfide ores. The foundations of the old cyanide mill are about all that remain on the site. Some water emanates as a spring from near the mill site (**Figure 9**). There are both waste rock (SBSI-99-83) and tailings (SBSI-99-85) at the Alice E Mill site. The mine wastes are less than 100 cubic meters and cover an area of about 0.12 hectare (0.3 acres). The tailings at the mill site contain about 2550 cubic meters of material and cover an area of about 0.5 hectare (1.2 acres). Because this mine was last operated in 1908, both the tailing and the waste rock piles are completely revegetated with pine trees, shrubs and grasses.

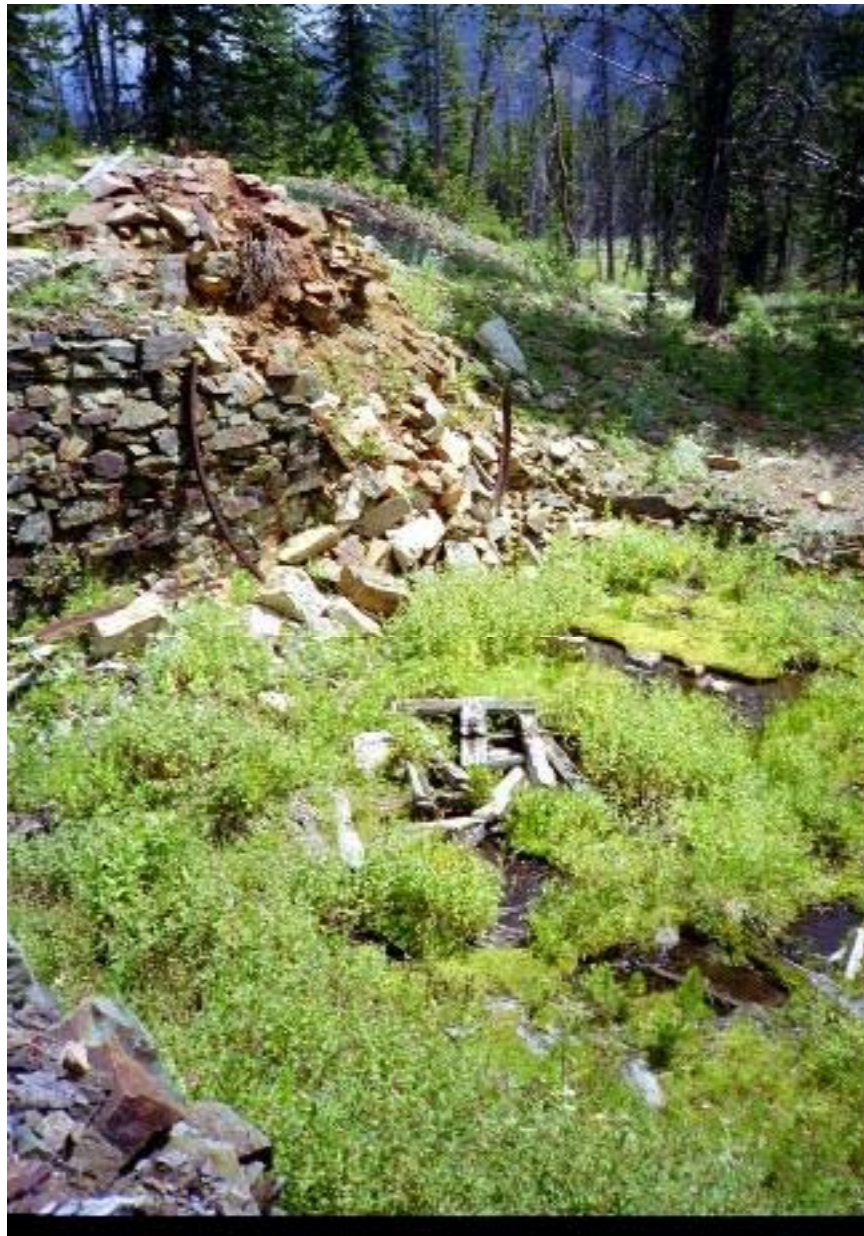


Figure 9. Alice E millsite showing seep originating from cutbank above stone mill foundation.

2.5.1.5 MINES IN THE MILLER MOUNTAIN AREA

There are a number of small underground mines developed midway up the eastern flank of the southern portion of Miller Mountain, generally downstream of the Miller Mountain road crossing of Miller Creek (**Figure 3**). Lovering (1929) indicates that most of these mines operated prior to his work in the area (mid-1920's) and probably as early as the late 1800's. Most of the mines are vein-type fracture fillings, which locally become narrow sulfide replacement zones along fracture and fault structures that crosscut limestone. Copper, silver and lead was produced from these predominantly galena and chalcopyrite-bearing quartz and carbonate veins. Minor amount of arsenopyrite, sphalerite, tetrahedrite and pyrite also occur in these deposits with quartz-sericite-chlorite alteration of the wall rock. None of these mines are thought to have any significant production, although Lovering speculates that they may have periodically been an important source of lead-silver ore for the Republic Smelter for short periods of time.

2.5.2 Recently Discovered Subsurface Deposits

In the late 1980's and early 1990's, CBMI discovered two large underground deposits that are both associated with the Homestake stock on the north end of Henderson Mountain. These deposits include the Miller Creek deposit and the Homestake Breccia pipe deposit (**Figure 3**). More detailed description of these deposits may be found in papers by Elliot et. al. (1992); Johnson and Meinert, 1991; and Kirk and Johnson, 1993).. During this same period of time another small breccia pipe deposit at the southwest end of Henderson Mountain called the Alice E Breccia Pipe was drill tested.

2.5.2.1 MILLER CREEK DEPOSIT.

The Miller Creek deposit is a tabular, statabound, contact-metasomatic, massive sulfide replacement deposit developed in the Meagher Limestone (**Figure 10**). The deposit is located in the subsurface adjacent to the Homestake Stock on the northwest flank of Henderson Mountain. The deposit contains high grades of gold, copper and silver mineralization. The deposit lies approximately 107 to 182 meters (350 to 400 feet) below the surface and is located immediately to the south and east of Daisy Pass (**Figure 3**). The strataform and selective bed replacement of the Meagher Limestone consists of sulfide-rich skarn (15-30% sulfide) and massive sulfides (>50% sulfide) consisting of specularite, magnetite, pyrite, red hematite, chalcopyrite, chlorite, quartz and clay minerals. Bedding dips about 7 degrees to the southwest toward Miller Creek. These replacements occur adjacent (0-180 meters, 0-600 feet) to high-angle felsic intrusive contacts of the Homestake stock to which it is spatially, temporally, and genetically related. Replacement deposits are as much as 27 meters (100 feet) thick adjacent to the intrusive contact, and thin to selective bed replacement at distances of 15 to 90 meters (50-300 feet) from the contact, and then to a featheredge at distance of 600 feet from the contact. The deposit is as much as 790 meters (2,600 feet) long, 180 meters (600 feet) wide and crescent shaped in plan view as replacement mineralization wraps around the sediment/intrusive contact with the Homestake stock (**Figure 3**). Drill results suggest that there is some 2.2 million tons of high sulfide-bearing rock present in the relatively shallow subsurface.

During the delineation phase of drilling, CBMI drilled a total of 35,000 meters (115,046 feet) in 224 core and reverse circulation drill holes in the Miller Creek deposit area (**Table 2-1**). Holes drilled during this program were abandoned by grouting the holes with cement from the bottom of the hole to a point 10-15 meters (30-50 feet) above the mineralized portion of the Meagher Limestone, then backfilling the drill holes with "Enviroplug" chips to within 3 meters (10 feet) of the surface and a cement plug at the surface.

Table 2-1
Number of Drill Holes in the New World Deposit Areas with Closure Estimates
New World District Response and Restoration Project
Miller Creek Response Action EECA

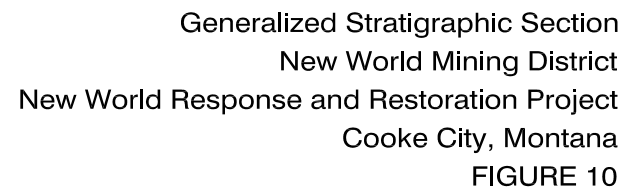
Deposit Area	# of holes	Footage	Qualitative Closure of Holes	Estimate of # of Open Holes
Como	158	>>8,376	Almost all open	146
Fisher Mountain	40	6,209	Almost all open	40
McLaren	343	> 69,979	Almost all open	271
Miller Creek	224	115,046	Almost all closed	27
Homestake	103	91,510	Almost all closed	15
Gold Dust Adit	33	23,331	Almost all open	28
Exploration	105	12,580	Mostly Closed	30
Total	1006	327,031		557

Approximately 10 of the 17 earliest drilled holes were located and abandoned in the manner described above. Some holes around the perimeter of the deposit were backfilled with “Enviroplug” chips only, and as many as 20 holes were lost prior to backfilling during exploration road construction.

2.5.2.2 HOMESTAKE DEPOSIT:

The Homestake Breccia Pipe is a funnel-shaped, phreatic, explosion-collapse breccia pipe (or diatreme) that vented to the surface, located largely in the subsurface at the north end of Henderson Mountain (**Figures 3 and 4**). The pipe is about 305 meters (1000 feet) in diameter at the surface on the top of Henderson Mountain and the venting distributed volcanogenic deposits some 762 meters (2,500 feet) down the paleotopographic surface on east side of Henderson Mountain (**Figure 4**). This deposit also contains very high grades of gold-copper and silver mineralization in a massive sulfide host. Within the Homestake Breccia Pipe deposit, clast dominated breccias of the Meagher and Pilgrim limestones, exhibiting a crude relict stratigraphy have been replaced by massive sulfide/iron oxide mineralization. The mineralogy is similar to that of the Miller Creek deposit described above. Drilling by Crown Butte Mines in the early 1990's (1990-1993) identified ore grade mineralization in the Homestake Breccia Pipe distributed over 305 meters (1000 feet) vertically within the pipe. Drilling within the pipe identified some 6.6 million tons of massive sulfide rock in the subsurface of Henderson Mountain.

A total of 27,900 meters (91,510 feet) of drilling was completed in 103 core and reverse circulation drill holes in the Homestake deposit area (**Table 2-1**). Almost all drill holes were abandoned by grouting the holes with cement from the bottom of the hole to a point 10 to 15 meters (30 to 50 feet) above the mineralized portion of the breccia, then backfilling the drill holes with “Enviroplug” chips to within 3 meters (10 feet) of the surface and a cement plug at the surface. Probably less than 15 of these holes remain open.



2.5.2.3 ALICE E BRECCIA PIPE

The Alice E breccia deposit is a collapse or subsidence type breccia pipe with little or no matrix material. The ground preparation for the deposit may be related to dissolution of the Meagher Limestone at depth. The material within the pipe shows no vertical streaming of breccia clasts, but rather a down-dropping of brecciated but otherwise relatively intact stratigraphy into a cylindrical shaped depression. The breccia clasts have been mineralized with disseminated sulfides (5-30%) and low-grade gold and copper (0.1 to 0.3%) mineralization. Nine exploration holes were drilled.

2.6 CLIMATE

The New World District has a continental climate modified by its mountain setting. It is characterized by large daily and annual temperature ranges and marked differences in precipitation, temperature, and wind patterns over distances of only a few kilometers.

Precipitation and temperature data have been collected periodically at Cooke City from 1967 through 1995 (EarthInfo, 1996). The Cooke City station is located at an elevation of 2273.8 meters (7,460 feet). The average annual precipitation for the period of record is 645 millimeters (mm) (25.38 inches). Temperatures are coldest in January with an average minimum of -16.5°C (2.4°F) and an average maximum temperature of -4.8°C (23.3°F). Temperatures are warmest in July with an average minimum temperature of 3.3°C (37.9°F) and an average maximum temperature of 22.8°C (73.1°F).

Precipitation and temperature vary with elevation, and freezing conditions can occur any day of the year. Precipitation records from a Natural Resources Conservation Service SNOTEL Station TX06 at an elevation of 2,770 meters (9,100 feet) in the Fisher Creek drainage indicate that the average annual precipitation at this location is 1,500 mm (60 inches). Fifty percent of the annual precipitation occurs between October and February, with January having the highest average monthly precipitation (14.4 percent) and August having the lowest average monthly precipitation (3.9 percent) (URS, 1998). Average annual snowfall at higher elevations is about 13 meters (500 inches) (USDA 1975).

A meteorological station was maintained in upper Fisher Creek near the proposed mill site for various periods during exploration activities by CBMI. Data collected from this site for the period May 1992 through August 1993 indicate an average wind speed of 2.4 meters/second (5.4 miles/hour) and a prevailing direction from the northwest (Gelhaus, 1993).

2.7 HYDROLOGY AND HYDROGEOLOGY

The Miller Creek drainage basin collects water from the south side of Daisy and Bull-of-the-Woods passes, the southwest flank of Henderson Mountain, and the east flank of Miller Mountain (**Figure 3**). Just east of Cooke City, Miller Creek flows into Soda Butte Creek, which flows westward into Yellowstone National Park.

Surface water discharge in the Miller Creek area is quite variable and seasonally dependent, with rapid flow response to snowmelt and summer precipitation events. Rain-on-snow events typically produce major spring and early summer peak runoff events. Significant diurnal variations also occur particularly during the peak snowmelt periods. Although a substantial number of summer and fall flow measurements have been made in the Miller Creek drainage, only a few winter and spring flow measurements have been made. As much as 90 percent of Miller Creek's discharge volume occurs between mid May and early August.

Groundwater occurs in two hydro-stratigraphic units in the upper Miller Creek basin: 1) surficial unconsolidated alluvial and colluvial deposits localized along drainages, and 2) fractured bedrock. Unconsolidated deposits that host groundwater consist primarily of narrow strips of alluvial/colluvial material deposited parallel to tributary channels and the main stem of Miller Creek. A somewhat broader expanse of alluvial valley fill occurs near and immediately upstream of the Miller Mountain road crossing with Miller Creek (**Figure 4**). Water in the lower reaches of Miller Creek (from just below the Miller Mountain road crossing to just above its confluence with Soda Butte Creek) flows through a narrow, incised valley along a very steep gradient channel with small waterfalls. Groundwater within unconsolidated sediments is recharged by direct infiltration of surface runoff and in some areas by discharge from bedrock seeps, springs, and fractures. Groundwater flow within unconsolidated material is parallel to topographic slope.

The primary porosity of bedrock units throughout the District is very limited. Most porosity and permeability is secondary, and results from fractures and faults in bedrock. Recharge to bedrock occurs primarily as direct infiltration of snowmelt and runoff, particularly where fractures daylight. The regional hydraulic gradient in bedrock is expected to follow topography from Daisy Pass, Henderson Mountain, and Miller Mountain toward Miller Creek. Preferential groundwater flow along the Crown Butte Fault, which controls the location of the Miller Creek valley, is described below.

The hydraulic conductivity of bedrock reflects the degree of fracturing and interconnectedness of fractures in the bedrock. For example, in 1996 Maxim performed pumping tests on well MW-5P located in the Miller Creek drainage at the base of Daisy Pass (**Figure 3**). Well MW-5P is completed in Wolsey shale within a zone of what is inferred to be intense fracturing along the Crown Butte Fault. Observation wells MW-5B and MW-5C are also completed in the Wolsey Shale and lie within approximately 30 meters (100 feet) of the pumping well. During one test, approximately 3 feet of draw down was measured in well MW-5P after it was pumped for 150 minutes at 400 L/sec (105 gallons per minute (gpm)) and little or no draw down was observed in the observation wells. Aquifer transmissivity could not be quantified by the pumping test. The test did demonstrate that fractures associated with faults are capable of transmitting large volumes of groundwater, in the plane of the fault, but at least in this case, very little at right angles to the fault. A pump test conducted on well MW-11P (**Figure 3**), which is completed in less fractured massive sulfide ore in the Meagher limestone and Wolsey shale 425 meters (1,400 feet) north of well MW-5P, demonstrated that unfractured bedrock is much less transmissive. Well MW-11 went dry with 5.2 meters (17 feet) of drawdown after it was pumped for two minutes at 11.4 L/min (3 gpm). The static water level in this well did not recover to pre-pumping within 24 hours of cessation of pumping. Packer tests in Tertiary intrusive rocks elsewhere within the District yielded hydraulic conductivity estimates ranging from 1×10^{-4} to 3×10^{-5} centimeters per second (cm/sec).

Fractures in bedrock create a high degree of anisotropy that controls local and regional groundwater flow. Although the regional hydraulic gradient generally follows topography, anisotropy due to fracture orientation creates preferential flow paths that often cut across potentiometric gradients. A groundwater tracer study conducted in the McLaren Pit area in 1997 and 1998 (Davies and Alexander, 1998) injected dye into Tracer No. 1, which is about 2.4 km (1.5 miles) to the north of the upper headwaters of Miller Creek, that yielded dye in MW-5P 28 days after injection. This demonstrates that groundwater can flow quite rapidly across topographic divides and between drainage basins. It is expected that there is large north-south component of flow near the Crown Butte fault. Groundwater velocity within fracture traces is probably several orders of magnitude greater than within unfractured bedrock. Based on the results of this tracer study the authors conclude “*It can be conjectured that the faulting associated with the Crown Butte fault hydraulically connects the fractures in the vicinity of Tracer 1 with well MW-5P*” (Davies and Alexander, 1998, p.8).

3.0 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

Numerous environmental samples have been collected from mine wastes and mine discharges present in the Miller Creek drainage basin to identify the source, nature, and extent of contamination. The data used to support this EE/CA includes geochemical analyses of solid samples collected from waste rock dumps; water quality data from surface water, adit discharges, and groundwater sources; and stream sediment data. In addition, Maxim has reexamined historical surface water data to assess metal loading in Miller Creek. In 2000, the U. S. Geological Survey (Cleasby and Nimick, 2002) conducted a detailed ionic tracer injection synoptic sampling study of the Miller Creek drainage and its tributaries in order to define sources of contamination. Recently, the Montana Department of Environmental Quality (MDEQ) prepared a draft report on Total Maxim Daily Load (TMDL) (MDEQ, 2002) evaluations conducted using existing data for the drainages in the New World District, including Miller Creek.

This section presents the data that characterize the sources, nature, and extent of mining-related contaminants in Miller Creek. Environmental data included in this discussion are mine waste, surface water, sediment, groundwater, and natural sources of contamination. The section concludes with a discussion of a conceptual model for contaminant sources and pathways of movement.

3.1 MINING-RELATED CONTAMINANT SOURCES IN MILLER CREEK

Mining-related contaminant source areas in the Miller Creek drainage are included in a list of prioritized sites for the entire District that was created using the Abandoned and Inactive Mines Scoring System (AIMSS) (Maxim, 2001a). This modified hazard ranking system (HRS) was developed for the Montana Department of Environmental Quality (MDEQ) Mine Waste Cleanup Bureau (Pioneer, 1995) to prioritize abandoned mine sites in Montana. AIMSS scoring was completed on 132 source areas using data collected in 1996, and 1999.

The AIMSS system ranks waste sources relative to each other using site-specific data and the HRS scoring algorithm. In preparing these AIMSS rankings, four distinct exposure pathways were evaluated -- groundwater, surface water, air, and direct contact. For each exposure pathway, three factors are evaluated: 1) likelihood of release; 2) waste characteristics; and, 3) potential receptors. The scores for the three factors are multiplied to derive a pathway score. Pathway scores are weighted more heavily toward certain situations and types of impacts. Higher weights are ascribed to the following: observed releases to groundwater and surface water, especially where an exceedance of a standard is documented; sources that are closer to a population base; and, large contaminant concentrations, large contaminant quantities, and/or large areas of disturbance.

Table 3-1 lists 47 mine waste sites located in the Miller Creek Drainage. Twenty-seven of these sites were ranked by the AIMSS scoring system, with the highest ranking site in Miller Creek being the Black Warrior Dump (also known as the Miller Creek Headwaters Dump One). This site ranked second overall in the District, primarily because the dump has high surface water and groundwater pathway scores. West Miller Creek Dump Two ranks 10th overall for sites on District Property, followed by eight other sites on District Property that are ranked in the top 50 sites in the District.

Twenty mine waste source areas are located on private or non-District Property and are primarily associated with the Alice E Mine and Millsite. The Alice E Mine complex is ranked 4th overall of the non-District property sites. Numerous other smaller sites in Miller Creek were not included in the AIMSS ranking, but, due to their small size, likely rank lower than the top 50 to 100 sites. The Cumberland Barrel Dump (**Figure 3**), which is unrated, contains rusted metal debris and some assay laboratory equipment, including ceramic crucibles that contain high concentrations of lead contaminants. While

this site is unrated, its proximity to Miller Creek and Cooke City place this site among those to be considered for cleanup. Dump volumes and areas are listed in **Table 3-1** and dump locations are shown on **Figure 3**. Volumes were calculated from field reconnaissance observations, and area estimates were interpreted from aerial photography by the Interagency Spatial Analysis Center.

3.2 MINE WASTE INVESTIGATION RESULTS

Waste rock and tailings samples were collected from many of the sites in the District and in Miller Creek during 1999, 2000, 2001, and 2002 by Maxim, and in 1996 by George Furniss on behalf of CBMI. Descriptions of individual mine waste sites visited are noted on *Source Area Site Forms* included in Appendix A. Mine waste samples were collected from dumps in the Miller Creek drainage following standard operating procedures referenced in the Site-Wide Sampling and Analysis Plan (SAP) (Maxim, 1999a). Samples were collected from hand dug test pits using a shovel. Subsample test pits were dug to a depth of about 18 inches. Field quality control samples were collected at a frequency of five percent of natural samples. Laboratory quality control samples included duplicates and matrix spikes. Quality assurance was completed according to the quality assurance project plan presented in the Site-Wide SAP. Precision and accuracy were within acceptable limits for all samples collected.

Mine waste and soil samples were placed in one gallon, heavy-duty, polyethylene bags and labeled with date, sampler, and sample number according to sample designation and labeling procedures. Composite samples were analyzed for saturated paste pH and electrical conductivity, total metals (arsenic, cadmium, copper, lead, mercury, and zinc), sulfur fractionation, and lime requirement. All samples were analyzed according to methods presented in the Site-Wide SAP.

3.2.1 Analytical Results

Electrical conductivity, pH and metal values are reported in **Table 3-2**. Acid-base accounting analytical results for samples collected from the mine waste dumps in the Miller Creek drainage are included in **Table 3-3**. A review of these two tables shows that mine waste materials are acidic and contain elevated metal concentrations. Acid base accounting data (**Table 3-3**) suggest that these materials are moderately to strongly acidic, with paste pH values as low as 2.2 standard units (s.u). Lime addition requirements ranging from 11 to 529 (average 114.3) tons/kiloton as calcium carbonate (CaCO_3) would be needed to adjust the pH of the mine waste to a pH of 7.0 s.u. Total sulfur contents range from 0.13 to 14.75%, with roughly equal amounts of reduced sulfide (nitric acid soluble) and oxidized sulfate (hydrochloric acid soluble), and slightly lower amounts of water soluble sulfur. Some of the total sulfur present in the dumps was measured in the residual fraction, which indicates that the minerals present in the waste have low reactivity in the strong acids used to digest the sulfur fractions. This material clearly has the potential to produce acidic, metalliferous water without amendment or treatment.

3.2.2 Erosional Sediment Hazard

The potential for sediment derived from mine waste dumps to erode into Miller Creek was calculated by Mark Story, the USDA-FS hydrologist for the project. This evaluation was completed as part of his sediment loading analysis for various drainage basins in the District (see Section 3.7). The sediment evaluation ranks three sources of sediment to the Miller Creek drainage: natural, roadway, and mine waste. Sediment loads derived from mine waste dumps in Miller Creek account for about 2.1 tons per year of the total sediment load of 27.3 tons per year in the entire Miller Creek drainage basin (about 8% of the total sediment load). A reduction in sediment load following revegetation of select mine waste dumps was also calculated by Story (2002), with a reduction of about 1.7 tons per year, or an 81% reduction, in the load contributed from mine waste.

Table 3-1
Miller Creek Source Area Ranking - Miller Creek Response Action EECA

Site No.	Site Name	Other Name	Material Type	Volume (cubic meters)	Area (hec-tares)	Mine Drainage	Flow (GPM)	Ground Water Pathway	Surface Water Pathway	Air Pathway	Direct Contact Pathway	Total Score	District Ranking
DISTRICT PROPERTY SITES													
MCSI-96-2	Miller Creek Headwaters Dump One	Black Warrior	waste	610	0.07	cladit	10	747226.20	240220.22	5201.20	436.54	9.9308	2
MCSI-99-79	West Miller Creek Dump Two	Grace Lode	waste	400	0.05	none	0	130290.62	1904.28	1121.18	1035.55	1.3435	10
MCSI-99-81	West Miller Creek Dump Four		waste	140	0.1	none	0	43430.21	634.76	11211.81	10355.47	0.6563	16
MCSI-96-6	Little Daisy Adit and Dump	Little Daisy	waste	680	0.2	adit	10	29887.54	703.02	507.31	42.95	0.3114	20
MCSI-99-80	West Miller Creek Dump Three		waste	30	0.02	none	0	13029.06	190.43	1121.18	1035.55	0.1538	25
MCSI-99-66	Miller Creek Headwaters Dump Two		waste	30	0.01	none	0	10091.87	952.14	1121.18	94.14	0.1226	28
MCSI-99-72	Miller Creek Dump One		waste	50	0.01	none	0	10091.87	952.14	112.12	9.41	0.1117	29
DCSI-99-91	Bull of the Woods Shaft/Dump		waste	20	0.01	none	0	7154.69	190.43	1121.18	94.14	0.0856	34
MCSI-99-101	West Miller Creek Dump Five		waste	20	0.04	none	0	4343.02	63.48	112.12	1035.55	0.0555	41
MCSI-99-67	Miller Creek Headwaters Dump Three		waste	20	0.01	none	0	3363.96	317.38	1121.18	94.14	0.0490	43
MCSI-99-102	Daisy Pass Dump Six (Crown Butte area)		waste	100	0.04	none	0	3444.67	64.29	113.55	9.64	0.0363	52
MCSI-99-71	Henderson Mountain Trench		waste	150	0.05	none	0	2917.94	55.08	9.73	0.38	0.0298	55
MCSI-96-1	Miller Creek Dump Two		waste	220	0.1	none	0	1171.99	404.30	750.84	32.80	0.0236	61
MCSI-96-7-1	Little Daisy Mill Site Dump One		waste	180	0.04	none	0	821.90	15.34	27.10	2.30	0.0087	71
MCSI-96-7-3	Little Daisy Mill Site Dump Three		waste	130	0.02	none	0	821.90	15.34	27.10	2.30	0.0087	71
MCSI-96-4	Lower Miller Creek Dump One		waste	30	0.05	none	0	548.90	51.44	60.57	5.12	0.0067	75
MCSI-96-7-2	Little Daisy Mill Site Dump Two		waste	30	0.01	none	0	246.57	4.60	27.10	2.30	0.0028	84
MCSI-99-48	Henderson Mtn Dump Three		reclaimed	0	* 0.13	none	0	43.77	0.08	97.29	81.66	0.0022	88
MCSI-96-5	Middle Miller Creek Trench		waste	20	0.01	none	0	62.32	22.29	31.05	1.74	0.0012	93
MCSI-99-77	West Miller Creek Dump One		explor trench	0	0.06	none	0	0.00	0.00	0.00	2.92	0.0000	113
MCSI-99-69	Miller Creek Trench		trench	0	0.09	none	0	0.00	0.00	0.00	0.27	0.0000	114
MCSI-99-85	Upper Miller Creek Trench	Black Warrior	subsidence	0	0.01	none	0	0.00	0.00	0.00	0.27	0.0000	114
MCSI-99-241	Daisy Pass Dump Five		waste	120	0.03	none	0						unrated
MCSI-99-243	Miller Creek Dump Three (North)		trench	0	nd	none	0						unrated
MCSI-00-103	Henderson Mountain Adit #1		waste	120	0.03	adit	0						unrated
MCSI-00-105	Little Daisy Below Road Dump Complex		waste	nd	nd	adit	0						unrated
--	Cumberland Barrel Dump		metal/debris	0	* 0.2	none	0						unrated
Total District Property				3.100	1.06								
SITES ON PRIVATE OR NON-DISTRICT PROPERTY													
MCSI-96-9	Alice E Pit and Dump Complex	Upper Alice E.	waste	2380	0.59	none	--	598325.83	4365.78	3855.65	2377.74	6.0892	4
SBSI-99-85	Alice E Mill Site	Lower Alice E.	tailings	2550	0.53	adit	1	92220.40	14947.91	74.97	692.90	1.0794	12
MCSI-96-3	Upper Miller Creek Dump	Black Warrior	waste	60	0.03	cladit	1	32600.20	18500.84	518.11	43.61	0.5166	12
MCSI-99-84	Alice E Dump Three		waste	160	0.01	none	0	860.59	11.56	20.41	19.40	0.0091	14
MCSI-99-83	Alice E Dump Two		waste	50	0.01	none	0	258.18	3.47	20.41	19.40	0.0030	15
MCSI-99-207	Alice E area		waste	nd	nd	nd	nd						unrated
MCSI-99-208	Alice E area		waste	nd	nd	nd	nd						unrated
MCSI-99-204-206, 209-212, 244	Alice E Dumps		prospect pits	nd	nd	nd	nd						unrated
MCSI-00-1	Miller Creek Dump Four		waste	40	0.05	none	0						unrated
MCSI-00-2	Miller Cr Dump Six		waste	30	0.05	none	0						unrated
MCSI-00-3	West Miller Cr Dump Seven		waste	20	0.01	none	0						unrated
MCSI-00-104	No Name Dump No. 2		waste	25	0.001	none	0						unrated
MCSI-99-242	Lower Miller Creek Dump Three (South)		trench	0	0.05	none	--						unrated

Notes: * - indicates area not included in total; nd = not determined

TABLE 3-2
CHEMICAL CHARACTERISTICS OF MILLER CREEK WASTE ROCK DUMP SAMPLES
New World Mining District Response and Restoration Project
Miller Creek Response Action EECA

Site No.	Site Name	pH (su)	Total Concentration (milligrams per kilogram)							
			Silver	Arsenic	Cadmium	Chromium	Copper	Mercury	Lead	Zinc
MCSI-99-71	Henderson Mountain Trench	3.4	<20	5	11	20	57	<0.5	<20	11
MCSI-96-6	Little Daisy Adit and Dump	5.7	<20	55.7	20.4	<5	217	1	262	210
MCSI-96-7	Little Daisy Mill Site Dump One	3.8	<20	37.7	13		138	<0.5	160	105
MCSI-96-1	Miller Creek Dump Two	3.1	<20	120	30	<6	245	0.56	120	61
MCSI-96-2	Miller Creek Headwaters Dump One (Black Warrior)	5.8	100	460	69	<6	1990	0.85	43100	8950
MCSI-96-2	Miller Creek Headwaters Dump One (Black Warrior)			54	7.76	11.2	981	0.93	14600	2490
MCSI-96-4	Lower Miller Creek Dump One	2.6	<20	51.7	18	<5	235	<0.5	324	121
MCSI-96-5	Middle Miller Creek Trench	4.6	<20	34.3	17.4	<5	294	<0.5	117	32.2
MCSI-99-102-01	Crown Butte area	5.2	<20	114	7	10	355	<0.5	569	127
Private or Non-District Property Sites										
MCSI-96-3	Upper Miller Creek Dump	2.8	<20	137	12	<5	372	<0.5	2810	554
MCSI-96-9	Alice E Pit and Dump Complex	2.2	63	91.8	36.3	<6	226	<0.5	595	332
MCSI-96-9	Alice E Pit and Dump Complex			17.4	0.8	<1.4	174	0.651	252	104
MCSI-96-9	Alice E Pit and Dump Complex			41.6	<0.59	12.3	120	0.215	3440	68
MCSI-99-83/84-01	Alice E Dump Two	2.9	<20	4	13	66	224	<0.5	92	33
	Average Background			105	24	5	995	2.27	204	150
Mine Waste	- Average*	3.8	31.0	87.4	19.7	12.2	402.0	0.6	4747.0	943.0
	- Minimum	2.2	20	4	0.59	1.4	57	0.215	20	11
	- Maximum	5.8	100	460	69	66	1990	1	43100	8950

Notes:

< indicates less than analytical detection limit

* indicates values less than detection limit assigned the analytical limit for average calculations

shading indicates value greater than three times background

average background concentrations calculated using five natural samples collected by George Furniss in 1996 for CBMI (Maxim, 2001a)

TABLE 3-3
ACID-BASE ACCOUNTING DATA FROM MILLER CREEK WASTE ROCK DUMP SAMPLES
 New World Mining District Response and Restoration Project
 Miller Creek Response Action EECA

Site No.	Site Name	Sample Date	Sulfate S (%)	Pyritic S (%)	Jarosite S (%)	Residual S (%)	NP (t/1000t)	ABP (t/1000t)	AP (t/1000t)	SMP pH (s.u.)	SMP lime (t/1000t)	Lime Requirement (t/1000t)
MCSI-99-71	Henderson Mountain Trench	08/18/1999	0.1	< 0.1	0.1	0.4	0	-15	15	5.3	8.9	34
MCSI-96-6	Little Daisy Adit and Dump	8/26/96	0.3	0.4	0.4	0.6	17	-22	39	6.4	3.0	33
MCSI-96-7	Little Daisy Mill Site Dump One	8/26/96	< 0.1	< 0.1	< 0.1	0.3	0	-8.8	8.8	6.1	4.5	21
MCSI-96-1	Miller Creek Dump Two	8/26/96	< 0.1	< 0.1	< 0.1	7.7	5	-237	242	4.6	12.7	314
MCSI-96-2	Miller Creek Headwaters Dump One (Black Warrior)	8/26/96	0.7	1.1	0.6	1.4	73	-18	91	6.4	3.0	28
MCSI-96-2	Miller Creek Headwaters Dump One (Black Warrior)	08/09/1993	< 0.01	3.2		4.36	166					89
MCSI-96-3	Upper Miller Creek Dump	8/26/96	0.2	0.2	0.3	0.2	0	-20	20	4.9	11.2	38
MCSI-96-4	Lower Miller Creek Dump One	8/26/96	< 0.1	< 0.1	< 0.1	0.8	0	-24	24	4.7	12.0	50
MCSI-96-5	Middle Miller Creek Trench	8/26/96	< 0.1	< 0.1	< 0.1	0.1	4	-0.1	4.1	6.3	3.5	7
MCSI-99-102-01	Crown Butte area	08/13/1999	0.1	0.4	0.2	0.7	9	-29	38	6.6	1.8	40
MCSI-96-9	Alice E Pit and Dump Complex	8/26/96	1.2	3.6	< 0.1	9.9	0	-423	423	4.7	12.0	542
MCSI-96-9	Alice E Pit and Dump Complex	08/10/1993	3.11	2.7		5.56	-3.11					325
MCSI-96-9	Alice E Pit and Dump Complex	08/10/1993	0.53	0.1		0.15	-2.68					13
MCSI-99-83/84-01	Alice E Dump Two	08/11/1999	0.1	0.2	0.3	0.8	3	-37	40	5.2	9.5	56
	Mine Waste	- Average	0.5	0.9	0.2	2.4	19.4	-75.8	85.9	5.6	7.5	114
		- Minimum	0.01	0.1	0.1	0.1	-3.11	-423	4.1	4.6	1.8	7
		- Maximum	3.11	3.6	0.6	9.9	166	-0.1	423	6.6	12.7	542

Notes: S = Sulfur; NP = Neutralization Potential; ABP = Acid/Base Potential; AP = Acid Potential; SMP = Shoemaker, MacLean, and Pratt;
 % = percent; t/1000t = tons per 1000 tons; s.u. = standard units; < indicates less than the detection limit;
 Lime Requirement calculated using the formula $[(\text{Pyritic S} \times 31.25) + (\text{Jarosite S} \times 23.44) + \text{SMP lime}] - \text{NP} \times 1.25$

3.3 AREAS OF ANOMALOUS METAL ENRICHMENT IN SOILS

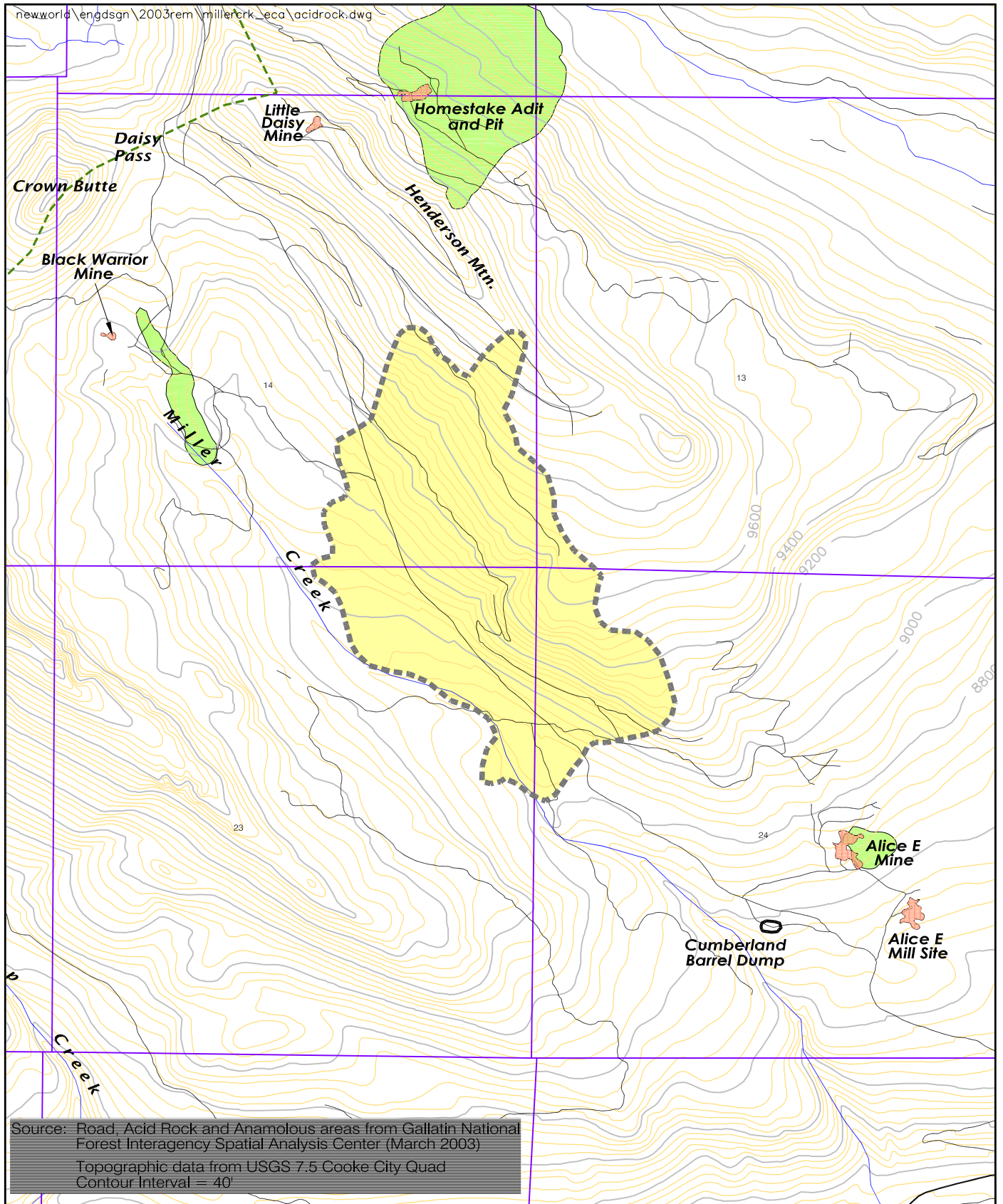
One of the most common techniques used by mining companies to explore for deposits hidden beneath soil covers is to sample soils for anomalous, naturally occurring concentrations of metals. District-wide soil sampling programs were conducted by a number of exploration companies (Kennecott, Rancher Exploration, Gulf Mineral Resources and Amoco Mineral Resources) in the 1970's and 1980's as a means of identifying drilling exploration targets for porphyry copper and molybdenum deposit. This soil sampling was conducted on 200-, 300-, and 400-foot grid spacings throughout the District. Metal values for gold, copper, and molybdenum were contoured to define areas of anomalous metal concentrations in soils, and these areas are shown on **Figure 11**. Large areas of anomalous soils with copper values greater than as 300 parts per million (ppm), molybdenum greater than 10 ppm, and gold greater than 0.27 ppm in soils were identified (**Figure 11**). Copper values in excess of 2,500 ppm (0.25 percent) were reported for select samples from the soil grid. These areas of anomalously high metal concentrations in soils represent a significant source of metals that could be carried in surface runoff. As described below, a large area of anomalously high metals concentrations in soils on the west flank of Henderson Mountain is likely contributing detectable dissolved and suspended copper load to Miller Creek during both high and low flow events, particularly in areas where soils have been disturbed by road building and on-going maintenance activities.

In addition to the areas identified with anomalous metals concentrations in soils, other areas of known and potentially acid generating rock were delineated and mapped by CBMI, usually based on sulfide content (**Figure 11**). Areas of known acid production are also commonly associated with anomalous metal concentrations. It is well known that products produced during the oxidation of sulfide minerals often result in an increase in acidity in water, and that the presence of acidic water greatly increases the solubility of metals. Examples of areas of known acid production include the McLaren Pit area, the Como Basin area, the Alice E Open Pit mine area, the Lulu Pass switch-backs (constructed on sulfide-rich Fisher Mountain Intrusive rock) between the Glengarry Mine and Lulu Pass, and a small area of sulfide mineralization along a fault in upper Miller Creek. Areas of potential acid production include almost the entire rock masses of the Fisher Mountain area, which is underlain by the Fisher Mountain Intrusive Complex and the Homestake Stock on the north end of Henderson Mountain. Both of these large intrusive bodies contain two to four percent disseminated sulfides throughout, with locally developed faults and fractures (high permeability zones) with sulfide contents as large as 15 percent. In addition, it is likely that the areas with anomalous metal contents in soils and intrusive rocks identified above are underlain by aerially extensive outcrops of sulfide-rich mineralization in intrusive rocks (Henderson Mountain stock along the central portion of Henderson Mountain).

Areas of known and potential acid production and other areas of anomalous metal concentration in soils and bedrock represent significant sources of contamination, which are often exacerbated by surface disturbances such as roads that expose these materials to ongoing erosion both on roadbeds and cut and fill slopes.






3.4 SURFACE WATER

A considerable amount of surface water flow and chemistry data has been accumulated for Miller Creek. In conjunction with their application for a hard rock mining permit, CBMI began comprehensive surface and ground water quality monitoring and discharge measurements in the Miller Creek drainage in 1989 that continued through 1996. More recent work by the USGS (Cleasby and Nimick, 2002), EPA, and the USDA Forest Service continued to build on the database and understanding of Miller Creek surface water characteristics. Water quality and flow data are available on the Internet from the New World project database at <http://www.fs.fed.us/rl/gallatin>.



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-  Area of Anomalous Metals Concentrations in Soils
-  Areas of Potential Acid Generation
-  Mine Waste Source Area
-  Forest Boundary
-  Road

**Areas of Anomalous Metal Concentrations
in Soils and Areas of Potential Acid Generation
New World Mining District
Response and Restoration
Cooke City Area, Montana
FIGURE 11**

3.4.1 Surface Water Flow in Miller Creek

Discharge rates have been measured at two stations SW-2 and SW-5 (**Figure 3**) at various times of the year from 1989 to 1995 and 1999 to 2002. A complete set of flow and water quality data for these two sampling sites are presented in **Table 3-4**. Flow at the upstream site (SW-2) ranges from a low of 0.27 cubic feet per second (cfs) in April of 2002 to as much as 48.7 cfs in June of 1990. Flow at the downstream site (SW-5, just above Miller Creek's confluence with Soda Butte Creek) ranges from a low of 0.34 cfs (September of 1995) to as much as 90 cfs in June of 1990. During 1990, numerous flow measurements at SW-2 and SW-5 were made between early June and late September. These data for the SW-5 station are plotted on **Figure 12**.

Figure 12 shows that peak runoff occurs during the height of snowmelt during the period from June through early July. The exact timing of peak runoff in a particular year is controlled by depth of snow pack and late spring-Early summer weather patterns

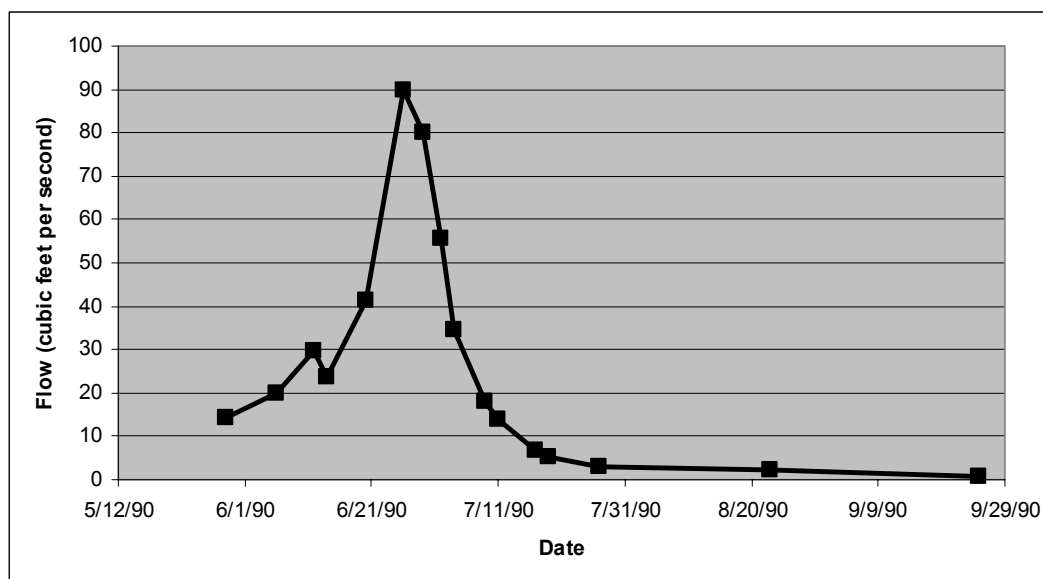


Figure 12. 1990 hydrograph of flow in Miller Creek measured at SW-5.

3.4.2 Surface Water Chemistry

In addition to the routinely sampled surface water stations located on Miller Creek (SW-2 and SW-5), several other sites, including stations AEC-1, MC-1, MC-2, MC-3, and MC-5 (**Figure 3**), were sampled during a 1990 synoptic sampling event. Water quality analyses from these surface water-sampling sites are presented below in **Table 3-4**.

Table 3-4 shows water in Miller Creek ranges from neutral (pH 7.0 s.u.) to slightly basic (pH 8.2 s.u.). This condition probably results from relatively high alkalinity introduced from the weathering of lime- and carbonate-rich sedimentary rocks and unconsolidated till distributed throughout the drainage. Metal concentrations are generally low, but there are exceedances of the State of Montana Water Quality Bureau Circular 7 (WQB-7) water quality standards for aluminum, copper, iron manganese, lead and zinc (**Table 3-4**). Metals that exceed state standards are highlighted in this table. Of the metals analyzed in water samples collected from stations SW-2 and SW-5, total recoverable copper exceeds the standards most often, and usually under conditions of high or intermediate flows (much less

commonly at low flow rates). Exceedances of other metals occur almost exclusively (with the exception of one zinc analysis) under very high flow conditions (greater than 30 cfs). The presence of these total recoverable metals in waters under high flow conditions suggests that metals may be transported as suspended or colloidal particles in the stream.

3.4.3 Adit Drainage

Water discharges from three adits in the Miller Creek drainage at the Little Daisy, Black Warrior and Henderson Mountain Adit No. 1 (surface water station M-25). In addition, there is a seep or spring that has been routinely sample at the Alice E Millsite (station AEC-1). Average water quality and flow data for these sites is presented in **Table 3-5**. Water collected from these adits is close to neutral in pH, with the exception of one of the two measurements of pH taken from the Henderson Mountain adit. Flows range from 0.01 liters per second (L/s) (0.09 gpm) at the Black Warrior Mine to as much as 0.42 L/s (6.7 gpm) at the Alice E mill-site seep. Each of the sites exceeds the standards for one or more metals (shaded cells on **Table 3-5**).

Similarly water flowing from the seep at the Alice E mill-site (**Figure 9**) flows almost immediately into colluvial and mine waste materials and does not obviously surface again. These waters exceed the standards for aluminum, copper iron, lead and manganese.

Water from the Black Warrior mine (**Figure 8**) seeps from the portal at rates ranging from about 0.01 to 0.07 L/s (0.09 to 1.1 gpm). It flows across and through mine wastes as a surface flow and also emanates as a toe seep from the waste. This water from the Black Warrior tributary (site #25) discharges directly to the uppermost reaches of Miller Creek. Although lead impacts to water quality in the main stream of Miller Creek have been identified, they were noted at only one USGS surface water sampling station (site 190), which is located immediately downstream from the Black Warrior Mine (Cleasby and Nimick, 2002).

The Henderson Mountain Adit (**Figure 3**) occurs the area of anomalously high metal concentrations in soil and intrusive rock associated with the Henderson Mountain Stock. Water flows from the adit range from 0.003 to 0.1 L/s (0.6 to 1.6 gpm) and contains aluminum (0.2 milligrams per liter [mg/L]) and copper (0.56 mg/L) concentrations that exceed WQB-7 water quality standards. Surface water flows in channels downstream from this adit are ephemeral and most times of the year are dry. The synoptic water-sampling event conducted by Cleasby and Nimick (2002) identifies copper loading to the main stem of Miller Creek at three sampling sites downgradient of the anomalous metal-bearing soils and the Henderson Mountain adit outflow.

3.4.4 Metal Loading to Miller Creek

There are three principal sources of information related to metal loading in Miller Creek, historic data, a USGS tracer study, and an MDEQ report on total maxim daily loads (TMDL) that was done using existing data for the drainages in the New World District, including Miller Creek. The following sections summarize this information.

TABLE 3-4
Flow and Water Quality Data from Miller Creek Surface Water Sites
New World Mining District Response and Restoration Project
Miller Creek Response Action EECA

Station	Date	pH (std. units)	Flow (cfs)	Concentration (milligrams per liter)							
				Total Recov. Aluminum	Total Recov. Cadmium	Dissolved Copper	Total Recov. Copper	Total Recov. Iron	Total Recov. Manganese	Total Recov. Lead	Total Recov. Zinc
SW-2	8/2/1989			<0.1	<0.001		<0.01	<0.03	<0.02	<0.01	<0.01
SW-2	9/16/1989	7.7	0.53	<0.1	<0.001		<0.01	0.08	<0.02	<0.01	0.04
SW-2	10/19/1989	7.8	0.71	<0.1	<0.001		0.01	<0.03	<0.02	<0.01	<0.01
SW-2	6/6/1990	7.1	10.90	<0.1	<0.0001		0.026	0.18	<0.02	<0.002	0.02
SW-2	6/7/1990		14.70								
SW-2	6/13/1990	7	19.20	<0.1			0.02	0.13			<0.01
SW-2	6/14/1990		13.50								
SW-2	6/20/1990	7.8	30.65	1.6			0.25	4.5			0.04
SW-2	6/22/1990		33.30								
SW-2	6/26/1990	7.4	48.70	0.9	0.0004		0.132	1.9	0.09	0.014	0.03
SW-2	6/28/1990		43.30								
SW-2	7/3/1990	7.4	44.00	0.2			0.02	0.49			<0.01
SW-2	7/5/1990		27.30								
SW-2	7/10/1990	7.2	17.70	<0.1			<0.01	0.06			<0.01
SW-2	7/11/1990	7.6	12.00								
SW-2	7/17/1990	7.1	7.40	<0.1			0.01	0.06			<0.01
SW-2	7/19/1990	7.2	4.40								
SW-2	7/27/1990	8.1	2.50	<0.1	<0.0001	0.006	0.007	<0.03	<0.02	<0.002	0.02
SW-2	8/23/1990	7.1	1.60			<0.01		<0.03		<0.002	0.04
SW-2	9/25/1990	8.2	0.60	<0.1	<0.0001		0.006	0.15	<0.02	<0.002	0.02
SW-2	6/5/1991	6.4	38.70	1.9	0.0001		<0.07	3.35	0.15	0.042	0.05
SW-2	7/9/1991	7.3	9.10	<0.1	<0.0001		0.027	0.06	<0.02		0.02
SW-2	8/13/1991	7.4	0.70	<0.1	0.0001		0.009	0.05	<0.02	<0.001	0.02
SW-2	9/24/1991	7.8	0.70	<0.1	0.0002	0.003	<0.007	0.04	<0.02	<0.002	<0.01
SW-2	5/27/1992	7.9	30.81	0.1	<0.0001	0.15	0.029	0.42	0.02	<0.002	0.03
SW-2	7/18/1992	7.8	3.50	<0.1	<0.0001	0.01	0.012	0.05	<0.02	<0.002	0.19
SW-2	9/22/1992	7.7	0.77	<0.1	<0.0001	0.005	0.009	0.04	<0.02	<0.002	0.01
SW-2	7/21/1993	7.4	7.24	<0.1	0.0001	0.009	0.029	0.04	<0.01	<0.002	0.0
SW-2	9/23/1993	8	0.43	<0.1	<0.0001	0.005	0.006	0.04	<0.01	<0.002	0.008
SW-2	6/16/1994	7.4	10.03	<0.1	<0.0001	0.014	0.017	0.05	<0.01	<0.002	0.01
SW-2	9/15/1995		0.86								
SW-2	9/26/1995		0.71								
SW-2	9/30/1999	7.9	0.84	<0.1	<0.0001		0.003	0.05	<0.005	<0.001	0.03
SW-2	4/14/2000	7.6	0.29	0.05	<0.0001		0.01	<0.05	<0.005	<0.001	0.02
SW-2	7/7/2000	8.2	9.20	<0.1	<0.0001		0.014	0.09	<0.005	<0.001	0.01
SW-2	10/10/2000	8	0.62	<0.1	<0.0001		0.001	0.13	<0.02	<0.003	<0.01
SW-2	4/19/2001	7.7	0.62	<0.1	<0.0001		0.008	0.04	<0.003	<0.001	<0.01
SW-2	6/26/2001	8.1	10.04	<0.1	<0.0001		0.015	0.07	<0.003	<0.001	<0.01
SW-2	10/12/2001	7.9	0.29	<0.1	<0.001		0.004	<0.05	<0.003	<0.001	0.08
SW-2	4/24/2002	7.6	0.27	<0.1	<0.0001		0.006	0.02	<0.003	<0.001	<0.01
SW-2	7/2/2002	7.9	14.80	<0.1	<0.0001		0.017	0.15	<0.003	<0.001	0.05
SW-2	Average	--	11.84	0.2	0.0002	0.006	0.026	0.40	0.02	0.005	0.03
MC-1	7/10/1990	8.1	2.84	0.1	0.002		<0.01	0.14	<0.02		0.02
MC-2	10/2/1989	7.8	0.38		<0.001		<0.01	0.1	<0.02		<0.01
MC-2	7/10/1990	7.7	6.35	0.1	<0.001		<0.01	0.14	<0.02		0.02
MC-3	7/10/1990	7.1	15.64	0.1	<0.001		0.02	0.05	<0.02		0.02
MC-5	10/2/1989	7.7	0.75		<0.001		<0.01	<0.03	<0.02		<0.01
MC-5	7/10/1990	7.9	21.05	0.1	<0.001		0.01	0.11	<0.02		0.11
Standard*				0.087	0.0018	0.008	0.008	0.3	0.05	0.0032	0.102

indicates flow greater than 30 cubic feet per second (cfs)

* shading indicates value exceeds standard (WQB-7); standards calculated for hardness of 83 milligrams per liter (average for Miller Creek)

TABLE 3-4 (continued)
 Flow and Water Quality Data from Miller Creek Surface Water Sites
 New World District Response and Restoration Project
 Miller Creek Response Action EECA

Station	Date	pH (std. units)	Flow (cfs)	Concentration (milligrams per liter)							
				Total Recov. Aluminum	Total Recov. Cadmium	Dissolved Copper	Total Recov. Copper	Total Recov. Iron	Total Recov. Manganese	Total Recov. Lead	Total Recov. Zinc
SW-5	9/15/1989	8	0.44	<0.1	<0.001		<0.01	<0.03	<0.02	<0.01	0.03
SW-5	10/20/1989	8	0.47	<0.1	<0.001		<0.01	<0.03	<0.02	<0.01	<0.01
SW-5	5/29/1990	7.8	14.34	0.2	<0.0001		0.019	0.34	<0.02	0.003	0.02
SW-5	6/6/1990	6.7	19.93	<0.1			0.01	0.16			0.01
SW-5	6/12/1990	7.4	29.84	0.1			0.01	0.3			0.09
SW-5	6/14/1990		23.60								
SW-5	6/20/1990	7.8	41.26	1.3			0.2	3			0.03
SW-5	6/26/1990	7.2	90.00	1.4	0.0004		0.153	3.22	0.13	0.022	0.04
SW-5	6/29/1990		80.00								
SW-5	7/2/1990	6.9	55.50	<0.1			<0.01	0.07			<0.01
SW-5	7/4/1990		34.40								
SW-5	7/9/1990	7.5	18.20	<0.1			<0.01	0.09			0.02
SW-5	7/11/1990	7.5	14.00								
SW-5	7/17/1990	7.4	6.70	<0.1			<0.01	0.05			0.02
SW-5	7/19/1990	7.5	5.10								
SW-5	7/27/1990	8.1	2.90	<0.1	<0.0001	0.004	0.004	0.08	<0.02	<0.002	<0.04
SW-5	8/23/1990	7.4	2.20			<0.01					
SW-5	9/25/1990	8.2	0.70	<0.1	<0.0001		0.003	<0.03	<0.02	<0.002	0.46
SW-5	6/5/1991	6.7	50.60	1.8	0.0004		0.09	3.12	0.11	0.003	0.01
SW-5	7/9/1991	6.8	11.10	<0.1	<0.0001		0.021	0.06	<0.02	0	0.02
SW-5	8/13/1991	8.1	0.70	<0.1	<0.0001		0.001	0.05	<0.02	<0.002	0.06
SW-5	9/24/1991	8.1	0.50	0.1	<0.0001	0.004	<0.006	0.05	<0.02	<0.002	0.01
SW-5	5/27/1992	7.9	38.13	0.2	<0.0001	0.006	0.029	0.54	0.02	0.002	0.02
SW-5	7/18/1992	7.7	5.50	<0.1	<0.0001	0.003	0.006	0.07	<0.02	<0.002	0.13
SW-5	9/23/1992	7.8	0.63	<0.1	<0.0001	0.004	0.004	0.06	<0.02	<0.002	<0.01
SW-5	7/21/1993	7.9	7.62	<0.1	<0.0001	0.005	0.009	<0.03	<0.01	<0.002	0.006
SW-5	9/23/1993	8	0.53	<0.1	<0.0001	0.002	0.005	<0.03	<0.01	<0.002	0.008
SW-5	6/16/1994	7.5	9.40	<0.1	<0.0001	0.001	0.002	0.04	<0.01	<0.002	0.008
SW-5	9/15/1995		0.55			0.007					
SW-5	9/26/1995		0.34								
SW-5	7/7/1999	8	22.33	0.1	<0.0001		0.014	0.13	<0.005	0.001	0.01
SW-5		Average	18.95	0.3	0.0003	0.006	0.028	0.5	0.03	0.004	0.05
SW-2 AND SW-5		Average		0.3	0.0003	0.006	0.027	0.4	0.02	0.005	0.03
% Exceeding Detection				25.5%	14.0%	89.5%	79.6%	80.0%	10.2%	15.9%	80.0%
Standard*				0.087	0.0018	0.008	0.008	0.3	0.05	0.0025	0.102

indicates flow greater than 30 cubic feet per second (cfs)

* shading indicates value exceeds standard (WQB-7); standards calculated for hardness of 83 milligrams per liter (average for Miller Creek)

Table 3-5
Water Quality and Flow Data for Adit Discharges from Underground Mines in Miller Creek
 New World Mining District Response and Restoration Project
 Miller Creek Response Action EE/CA

Old Designation Sample ID Location	M-1 MCSI-96-6 Little Daisy Adit	M-8 MCSI-96-2 Black Warrior Adit	AEC-1 SBSI-99-85 Alice E Mill Site	M-25 Henderson Mt.	Standard Hardness=100
METALS (milligrams/liter)					
Aluminum (dissolved)	<0.1	<0.1	<0.1		0.087
Aluminum (total recov.)	0.1	<0.1	0.8	0.2	0.087
Arsenic (dissolved)	<0.003	<0.003	<0.003		0.018
Arsenic (total recoverable)	<0.003	<0.003	<0.003	<0.005	0.018
Cadmium (dissolved)	<0.0001	0.0011	<0.0001		0.0025
Cadmium (total recoverable)	<0.0001	0.002	<0.0001	<0.001	0.0025
Copper (dissolved)	0.002	0.004	0.009		0.0093
Copper (total recoverable)	0.013	0.015	0.013	0.56	0.0093
Iron (dissolved)	<0.01	0.07	0.08		0.3
Iron (total recoverable)	1.05	0.55	1.59	<0.03	0.3
Lead (dissolved)	0.001	0.008	<0.001		0.0032
Lead (total recoverable)	0.047	0.066	0.007	<0.01	0.0032
Manganese (dissolved)	0.151	0.006	0.008		0.05
Manganese total recoverable)	0.180	0.023	0.059	<0.02	0.05
Zinc (dissolved)	<0.01	0.22	0.02		0.12
Zinc (total recoverable)	<0.01	0.42	0.05	0.1	0.12
IONS (milligrams/liter)					
Acidity as CaCO ₃	<2	<2	<2		
Alkalinity Bicarbonate as HCO ₃	200	113	12	4	
Alkalinity Carbonate as CO ₃	0		0	0	
Alkalinity Total as CaCO ₃	164	93	10	5	
Chloride	<4	<1	<1	<1	
Sulfate	201	43	23	20	500
Calcium	111	47	9	4	
Hardness as CaCO ₃	417	142	31	12	
Magnesium	34	6	2	<2	
Potassium	1	<1	<1	1	
Sodium	3	<1	1	1	
FIELD PARAMETERS					
Temperature (°C)	3.4	4.5	9.1	7.5 - 13.1	
pH (standard units)	6.97	7.49	6.32	5.6 - 7.0	6.5
Specific Conductance (mmhos/cm)	657	248.2	69.29	53	
Total Dissolved Solids (milligrams/liter)	457	169.7	46.45		500
Oxidation/Reduction Potential (millivolts)	264	270	276		
Ferrous Iron (Fe+2, mg/l)	<0.01	0.02	0.05		
Flow (gallons per minute)	1.93	0.09 - 1.1	6.7	0.6 - 1.6	

Note: shaded cells exceed surface water standards (MDEQ, WQB-7, 2002)

3.4.4.1 HISTORICAL DATA AND METAL LOADING

On July 10, 1990, CBMI conducted a synoptic sampling of Miller Creek using surface water stations MC-1, MC-2, MC-3, SW-2, MC-5, and AEC-1 (**Figure 3**). The samples sites are listed in order from north to south (upstream to downstream) with the exception of AEC-1, which is located on a tributary to Miller Creek sampled below the Alice E Mine site. Unfortunately, the SW-5 surface water sampling station was not sampled on July 10. Water quality and flow data for this sampling event are presented in **Table 3-6**.

Station	ph (s.u.)	Flow (cfs)	Flow (L/sec)	Total Recoverable Concentration (milligrams per liter)						Load	
				Alu- minum	Cad- mium	Copper	Iron	Man- ganese	Zinc	Iron mg/sec	Iron kg/day
AEC-1	6.9	0.7	19.8	<0.1	<0.001	<0.01	0.12	<0.02	0.01	2.4	0.21
MC-1	8.1	2.84	80.43	<0.1	0.002	<0.01	0.14	<0.02	0.02	11.3	0.97
MC-2	7.7	6.35	179.83	<0.1	<0.001	<0.01	0.14	<0.02	0.02	25.2	2.18
MC-3	7.1	15.64	442.92	<0.1	<0.001	0.02	0.05	<0.02	0.02	22.1	1.91
SW-2	7.2	17.70	501.26	<0.1	--	0.01	0.06	--	<0.01	30.1	2.60
MC-5	7.9	21.05	596.14	<0.1	<0.001	0.01	0.11	<0.02	0.11	65.6	5.67
SW-5*	7.5	18.2	515.42	<0.1	--	<0.01	0.09	--	0.02	46.4	4.01

Notes: * - Data for SW-5 was collected on July 9, 1990.

-- indicates not analyzed; lead was not analyzed in any samples collected during the synoptic sampling event

s.u. = standard units; cfs = cubic feet per second; L/sec = liters per second; mg = milligrams; kg = kilograms

A review of **Table 3-6** shows that many of the chemical analysis for metals are below the reporting limit. While these are not useful for calculating metal loads, iron concentrations are all above reporting limit, and are shown in the table. Iron loads were calculated by multiplying the iron concentration detected in a water sample by the flow rate measured in the creek at the time the sample was collected. Iron loads generally increase with distance downstream. One reach shows a decrease (12% percent) in iron load compared to sampling sites immediately upstream (MC-2) and downstream (MC-3). Iron concentrations did not exceed water quality standards during this sampling event and the calculated loads are about 50 percent lower than those typically calculated for more severely impacted streams elsewhere in the District such as Fisher Creek (10.6 kg/day or 24.3 pounds per day).

Other historic flow and water quality data are available for surface water stations SW-2 and SW-5 when both sites were sampled on the same day. In 1990, both sites were sampled on the same day nine times between June and September (high and low flow conditions). In 1991 and 1992, both of sites were sampled over approximately the same period of time but less frequently (1991, four sampling events; and 1992, three sampling events). According to **Table 3-4**, copper concentrations exceed water quality standards more frequently than other metals under high, moderate and occasionally low flow conditions. For this reason, copper loads were calculated for SW-2 and SW-5 to assess metal loading to Miller Creek between these two stations. Copper loading results are presented in **Table 3-7**.

TABLE 3-7 Flow and Copper Concentrations and Load from Miller Creek Surface Water Stations SW-2 and SW-5 New World Mining District Response and Restoration Project Miller Creek Response Action EE/CA				
Station	Date	Flow (liters/second)	Total Recov. Copper (milligrams/liter)	Copper Load (kilograms/day)
SW-2	6/6/1990	308.69	0.026	0.693
SW-2	6/13/1990	543.74	0.02	0.940
SW-2	6/14/1990	382.32		
SW-2	6/20/1990	868.01	0.25	18.749
SW-2	6/22/1990	943.06		
SW-2	6/26/1990	1379.18	0.132	15.729
SW-2	6/28/1990	1226.26		
SW-2	7/3/1990	1246.08	0.02	2.153
SW-2	7/5/1990	773.14		
SW-2	7/10/1990	501.26	<0.02	
SW-2	7/10/1990	501.26	0.01	0.433
SW-2	7/11/1990	339.84		
SW-2	7/17/1990	209.57	0.01	0.181
SW-2	7/19/1990	124.61		
SW-2	7/27/1990	70.80	0.007	0.043
SW-2	7/27/1990	70.80	0.01	0.061
SW-2	8/23/1990	45.31		
SW-2	9/25/1990	16.99	0.006	0.009
SW-2	6/5/1991	1095.98	0.07	6.629
SW-2	7/9/1991	257.71	0.027	0.601
SW-2	8/13/1991	19.82	0.009	0.015
SW-2	9/24/1991	19.82	0.007	0.012
SW-2	5/27/1992	872.54	0.029	2.186
SW-2	7/18/1992	99.12	0.012	0.103
SW-2	7/18/1992	99.12	0.013	0.111
SW-2	9/22/1992	21.81	0.009	0.017
SW-5	6/6/1990	564.42	0.01	0.488
SW-5	6/12/1990	845.07	0.01	0.730
SW-5	6/20/1990	1168.48	0.2	20.191
SW-5	6/26/1990	2548.80	0.153	33.693
SW-5	6/29/1990	2265.60		
SW-5	7/2/1990	1571.76	<0.01	
SW-5	7/4/1990	974.21		
SW-5	7/9/1990	515.42	<0.01	
SW-5	7/11/1990	396.48		
SW-5	7/17/1990	189.74	0.01	0.164
SW-5	7/19/1990	144.43		
SW-5	7/27/1990	229.39	0.004	0.079
SW-5	8/23/1990	62.30		
SW-5	9/25/1990	19.82	0.003	0.005
SW-5	6/5/1991	1432.99	0.09	11.143
SW-5	7/9/1991	314.35	0.021	0.570
SW-5	8/13/1991	19.82	0.001	0.002
SW-5	9/24/1991	14.16	0.006	0.007
SW-5	5/27/1992	1079.84	0.029	2.706
SW-5	7/18/1992	155.76	0.006	0.081
SW-5	9/23/1992	17.84	0.004	0.006

Note: < indicates less than detection limit

Figure 13 is a graph showing copper loading at stations SW-2 and SW-5 between June and September 1990. Copper load values peaked at these stations in early June and early July, respectively, followed by a decrease in load from mid-July through September. Based on the annual hydrographs for Daisy and Fisher Creeks, low flow and load conditions would presumably continue in Miller Creek through the fall, winter and early spring.

Data in **Table 3-7** indicate that the seasonal increase in loads result from both an increase in flow and an increase in concentration during the periods of greater copper loading. Flows measured at SW-5 between early June and mid-July are nearly 20 times greater than the flows measured during low flow periods, and copper concentrations increase by a factor of about 50 (from 0.004 to 0.200 mg/L) during the same period of time. The high flow is in response to snowmelt conditions, and the increase in copper concentration may be related to erosion and transport of metals from contaminated wastes and soils as suspended sediments, colloids, or remobilized chemical precipitates. Dissolved copper data are limited in the historic database, so the primary transport mechanism for copper (dissolved or suspended) during high flow is not known.

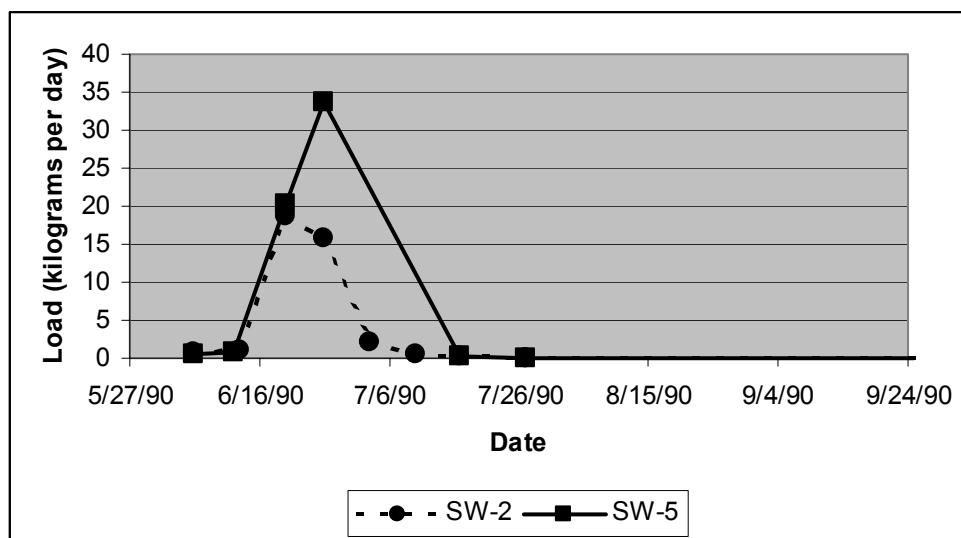


Figure 13. Graph showing copper loading at stations SW-2 and SW-5, June through September 1990.

Figure 14 shows the copper loads between June 1990 and September 1992 for both the SW2 and SW-5 sites. A similar pattern of increased loading in the late spring to early summer is evident and presumably sharper peaks would have occurred in 1991 and 1992 had samples been collected more frequently during critical high flow periods.

Assuming that high flow conditions occur over a period of 8 weeks (56 days from mid-May through mid-July) with a copper loading rate of about 7.5 kg/day (a calculated average of high flow data in **Table 3-7**), and low conditions apply for the remainder of the year (296 days) with copper loading at about 0.05 kg/day, the resulting estimated annual copper loading rate to Miller Creek would be about 435 kilograms per year (960 pounds per year). Of this total, 420 kilograms (925 pounds), or 96.5%, would be contributed during the 8 weeks of high flow; the remaining 14.8 kilograms (33.26 pounds), or 3.5%, of the copper load is contributed over the remaining 10 months of the year. This demonstrates that the majority of annual copper loading to Miller Creek occurs during the very short period of high flow conditions.

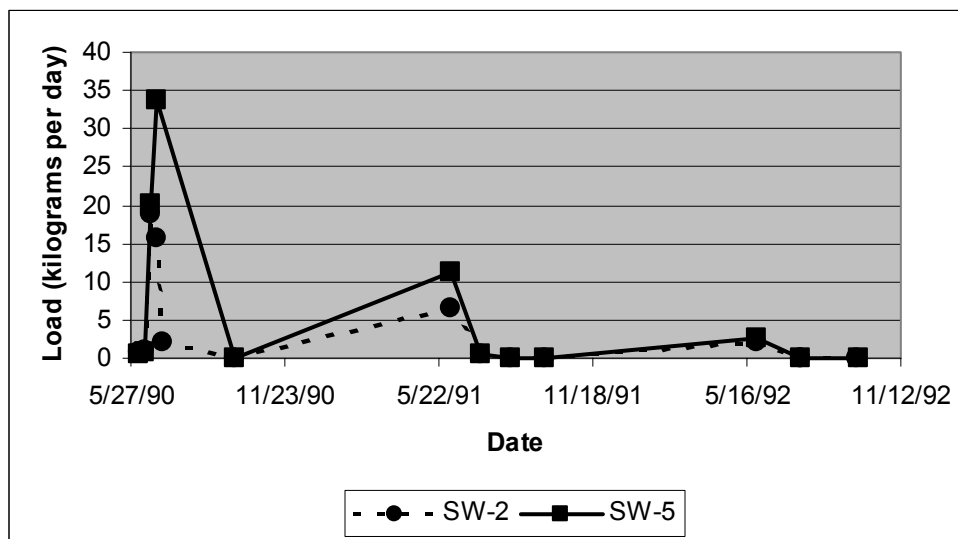


Figure 14. Graph showing copper loading at stations SW-2 and SW-5, June 1990 through September 1992.

3.4.4.2 TRACER INJECTION AND SYNOPTIC SAMPLING STUDY

In 2000, Cleasby and Nimick (2002) conducted a detailed and systematic synoptic sampling study of Miller Creek. The objective of their study was to quantify metal concentrations in surface water and identify inflows from tributaries, adits, seeps, and springs that contain elevated concentrations of metals and contribute to loading in Miller Creek. Their sampling involved the injection of a chloride tracer combined with other mechanical methods to determine changes in flow volume, and synoptic surface water sampling of 55 stations along Miller Creek. Surface water samples were analyzed for pH, calcium, sodium, chloride, sulfate and a suite of dissolved and total recoverable metals including aluminum, copper, iron, lead, and zinc. The synoptic sampling was conducted on August 30, 2000, and represents low flow conditions (26.9 L/s; 0.95 cfs; at SW-5) in Miller Creek.

Study results indicate that under low flow conditions, most of the water in the main trunk stream of Miller Creek appears unaffected or only modestly affected by historical mining disturbances or the weathering of naturally occurring mineralized country rock. Generally, surface water samples exhibited near-neutral to slightly basic pH, and metal concentrations were below the Montana WQB-7 standards for chronic aquatic life criteria. The only exception was one lead analysis immediately below the Black Warrior mine outflow (0.015 mg/L lead). A concentration of 0.005 mg/L was measured in Miller Creek at Cleasby and Nimick station 190 (190 feet downstream from the headwaters) (the standard is 0.0032 mg/L). Lead loading at this site was calculated to be 0.27 grams/day (0.0006 pounds per day). At Cleasby and Nimick station 400 (the next station downstream on the main stem), lead values were below detection at less than 0.001 mg/L.

Further downstream, three left bank (east side) tributary sites with elevated copper concentrations (0.029 to 0.063 mg/L) enter Miller Creek within approximately 300 meters (1,000 feet) upstream of SW-2 and contribute about 96% of the total copper load in Miller Creek. The three combined inflows raised copper concentrations in the main trunk from less than 0.001 to 0.003 mg/L upstream, to 0.003 to 0.006 mg/L downstream (chronic aquatic life standard is 0.0093 mg/L). Cleasby and Nimick (2000) suggest that the source of this water may be diffuse drainage across calcium poor source rock of a different composition than the calcium-rich sediments weathering elsewhere throughout most of the Miller Creek valley. This hypothesis is based on atypically low calcium concentrations and relatively

higher copper concentrations in the surface water samples from the three inflows. In addition, calcium and copper concentrations detected in samples from the three inflows are similar to concentrations detected in water draining from the Henderson Mountain Adit No. 1 that is driven into the Henderson Mountain rhyodacite porphyry upslope from the three inflows producing the high copper concentration in Miller Creek. This area of the Henderson Mountain stock is known for its anomalously high metal concentrations in both soils and bedrock (discussed previously). It is likely that the modestly elevated copper concentrations are the result of drainage originating in the metal-enriched and anomalous soils derived from mineralization in the Henderson Mountain stock.

3.4.4.3 TMDL STUDY

In 2001, MDEQ began developing statewide TMDL water quality restoration plans for impacted streams on a watershed planning area basis. One of the first draft reports to be issued was for non-point sources on three drainages in the Cooke City area. Non-point source pollution is defined as coming from diffuse, land extensive activities, which do not require a discharge permit. In the Cooke City area it was determined that metals and sediment from historic and abandoned mining activities contaminate several streams.

The objective of the TMDL restoration plan was to develop a mechanism to mitigate damage from past mining activities and protect water quality by imposing TMDL standards on the creeks. To accomplish these goals, the Cooke City TMDL study established targets “which included numeric values for aquatic life support (metals, pH); numeric values for drinking water/domestic use support (metals); elimination of objectionable deposits and turbidity from metal precipitates (metals/pH); non-toxic levels in stream sediments (metals); biota at greater than or equal to 75 percent of reference conditions (all pollutants); and stream habitat conditions within 25 percent of reference stream (sediment)”(MDEQ, 2002))

Miller Creek was one of the three watersheds studied using existing water quality data. **Table 3-8** (from MDEQ, 2002) presents a summary of the observations based on the analysis of this historically collected data. In summary, the MDEQ evaluation identified exceedances of standards for copper during many high flow and some low flow conditions. Iron, manganese, aluminum, and cadmium exceeded the standards only occasionally under high and very high flow conditions. Zinc chronic aquatic life standards were exceeded in three sampling events at both high and low flow conditions. It was also noted that there were anomalously high copper concentrations in stream sediments.

3.5 STREAM SEDIMENT DATA

Sediments have apparently been transported downstream and at least locally redeposited as channel fill and overbank deposits along Miller Creek. These sediments are locally sulfide and metal-enriched. Stream sediment data were collected and analyzed from Miller Creek in the synoptic sampling study conducted by Cleasby and Nimick (2002). Stream sediments were collected at sixteen sites along the Miller Creek drainage. The samples were analyzed for leachable metals using a partial digestion of the samples in a hydrochloric acid-hydrogen peroxide leach. Thirty-five metals were analyzed by inductively coupled plasma-atomic emission spectroscopy techniques.

TABLE 3-8
MILLER CREEK METALS IMPAIRMENT SUMMARY
New World District Response and Restoration Project
Miller Creek Response Action EECA

Pollutant	Sampling Results	Water Quality Standard Concern
Copper	1 – 200 ug/l	Consistently > 4.7 ug/l chronic aquatic life (during high flow) ¹ Sometimes > 7.3 ug/l chronic aquatic life (during low flow) ¹ Often > 6.6 ug/l acute aquatic life (during high flow) ¹ Results in elevated copper levels in sediment
Iron	<30 – 3220 ug/l	Consistently >1000 ug/l chronic aquatic life (during high flow only) Consistently >300 ug/l domestic/drinking water use (higher flows)
Manganese	<10 – 130 ug/l	Consistently >50 ug/l domestic use (during high flow only)
Aluminum	<100 – 1800 ug/l (total recoverable)	Lack of corresponding dissolved aluminum data at high flow conditions when total recoverable values are very high leaves open the possibility of a water quality concern at high flow
Zinc	<10 - 460 ug/l	1 detection >61 ug/l chronic & acute aquatic life (during high flow) ¹ 2 detections >94 ug/l chronic & acute aquatic life (during low flow) ¹
Cadmium	<0.1 – 0.4 ug/l	>0.15 chronic aquatic life (during very high flow only) ¹
Lead	<2 – 22 ug/l limited detections	Sometimes >1.2 ug/l chronic aquatic life (during high flow) ¹ Sometimes >2.2 ug/l chronic aquatic life (during low flow) ¹ One value > 15 ug/l human health standard Results in elevated lead levels in sediment

Note: ¹ Standards reflect adjustments for water hardness, which varies during lower flow periods (generally late summer or fall) and higher flow periods (generally spring/early summer runoff) in Miller Creek; the lower flow hardness value used for Miller Creek is 75 mg/L as calcium carbonate; and the higher flow hardness value is 45 mg/L as calcium carbonate. Table from MDEQ (2002).

Four metals were found to have anomalous concentrations in surface waters and sediments including cadmium, copper, lead, and zinc (**Table 3-9**). Leachable concentrations of these metals were significantly higher at the collection site at the confluence of water from the Black Warrior mine and the main stem of Miller Creek (Cleasby and Nimick station 25). Compared with sampling station zero at the headwaters of Miller Creek, the sediments at the Black Warrior confluence site were five-times greater in leachable cadmium, 20 times greater for lead, and 11 times greater for zinc. However, leachable metal concentrations at the next sampling site downstream from the Black Warrior mine (Cleasby and Nimick station 190) were only slightly higher than those reported for station zero.

Leachable copper concentrations increased from Cleasby and Nimick station 190 (below the Black Warrior mine) downstream to Cleasby and Nimick station 7120 (SW-2). At station 7120, leachable copper reached its highest concentration at about 500 parts per million (ppm) and remained at this approximate concentration level over the lower portion of Miller Creek. The increase in leachable copper is likely related to sediment derived from the area of anomalous metal laden soils and bedrock (**Figure 11**) associated with the Henderson Mountain stock, which outcrops upgradient and adjacent to the SW-2 site on the southwestern flank of Henderson Mountain.

Table 3-9
Leachable Metals Concentrations in Streambed Sediment Samples Collected in Miller Creek*
New World Mining District Response and Restoration Project
Miller Creek Response Action EECA

SITE	Leachable Concentration (parts per million)						
	Arsenic	Cadmium	Chromium	Copper	Lead	Silver	Zinc
0	< 6	3	9	78	230	< 1	< 1
25	10	17	7	330	4500	10	1
190	< 6	3	7	67	260	< 1	< 1
1020	8	3	3	130	110	1	< 1
1170	< 6	3	5	120	150	< 1	< 1
2225	< 6	3	4	120	130		< 1
2995	< 6	3	5	160	150	1	< 1
3205	< 6	2	10	320	180	3	< 1
3225	< 6	3	8	240	170	2	< 1
3910	< 6	2	6	220	160	2	< 1
4100	< 6	2	8	200	140	1	< 1
5190	< 6	2	12	250	150	1	< 1
7120	< 6	2	13	490	160	1	< 1
10120	< 6	2	12	360	140	1	< 1
12295	< 6	2	16	480	150	1	< 1
14930	7	2	16	460	150	1	< 1
Average**	4	3	9	252	433	1.8	0.5
Average Background	2	5	13	63	51	na	31
% Exceeding Detection	25.0%	100.0%	100.0%	100.0%	100.0%	80.0%	6.3%

< less than analytical detection limit

* Data from Cleasby and Nimick (2002)

** < detection limit values assigned half detection limit for average calculations

3.6 GROUNDWATER

Groundwater chemistry and flow characteristics are not as well documented as surface water chemistry. There are six groundwater monitoring wells in the Miller Creek watershed and numerous springs. This section summarizes water quality data from these sources.

3.6.1 Groundwater Characteristics

Four of these wells (MW-5P, a pumping well; MW-5A, MW-5B, and MW-5C observation wells) are located along and near the Crown Butte Fault Zone in upper Miller Creek (**Figure 3**). These wells were installed for both water quality monitoring and aquifer testing purposes. Another well, MW-1 IP, is located near Daisy Pass, and the last well, MW-6, is located on the southwest flank of Henderson Mountain near the Alice E Mine. These wells have been monitored intermittently since 1989.

Water level measurements indicate that the potentiometric surface in bedrock wells in Miller Creek is directly influenced by the snow-melt event. Static water level changes over the period from June through October of 1991 in each of these wells are depicted in **Figure 15**. Static water levels in upper Miller Creek (MW-5) area dropped by as much as 4.7 meters (15.3 feet) from June through October of 1991. In the Alice E Mine area (MW-6) water levels dropped by 1.6 meters (5.5 feet) over the same period of time.

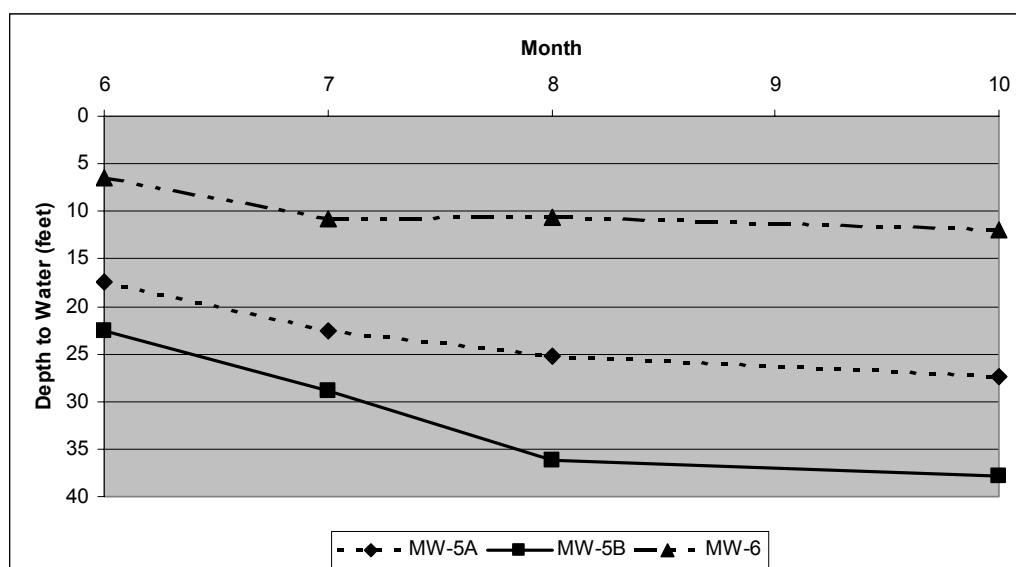


Figure 15. Graph showing changes in water levels in Miller Creek wells.

Water quality data for select metals, SC, and pH from these wells are reported in **Table 3-10**. There is no water quality data for well MW-1 IP, as this well was only used for pump testing. For the MW-5 nest of wells in upper Miller Creek, groundwater is nearly neutral in pH and there are no exceedances of MDEQ's WQB-7 human health standards. However, groundwater from well MW-6 located immediately downgradient of the Alice E Mine is acidic (pH values of 3.3 to 5.5), and human health standards are exceeded for arsenic, cadmium, manganese, and lead.

3.6.2 Spring Data

Spring data is often used as an indicator of groundwater quality and flow. More than 60 springs have been located, characterized, and sparingly sampled in the Miller Creek drainage since 1989. Hydrometrics, beginning in 1989, collected the first spring data for CBMI (Hydrometrics, 1990). Springs throughout the District were located using aerial photographs and the USGS topographic map. Field parameters (flow, SC, pH, and temperature) were measured, and selected samples were submitted for chemical analysis. Approximately 31 springs were mapped and sampled in Miller Creek.

TABLE 3-10
Groundwater Concentrations of Selected Parameters
New World Mining District Response and Restoration Project
Miller Creek Response Action EE/CA

Well ID	Date	pH (s.u.)	Conduc- tance (umhos/cm)	Dissolved Concentration (milligrams per liter)							
				Aluminum	Arsenic	Cadmium	Chromium	Copper	Manganese	Lead	Zinc
MW-5A	09/28/1989	7.6	166	0.1	0.005	0.001		0.01	0.02	0.01	0.02
MW-5A	07/25/1990	7.8	180	0.1	0.005	0.0002	0.02	0.005	0.02	0.005	0.05
MW-5A	08/22/1990	6.7	126	0.1	0.005	0.001	0.02	0.01	0.02	0.01	0.06
MW-5A	10/11/1990	7.5	156	0.1	0.005	0.001	0.02	0.01	0.02	0.01	0.02
MW-5A	07/11/1991	7.2	141	0.1	0.005	0.0002	0.02	0.001	0.02	0	0.01
MW-5A	10/01/1991	7.1	133	0.1	0.005	0.0002	0.02	0.001	0.02	0.002	0.01
MW-5A	07/28/1999	7	125	0.1		0.0001		0.001	0.005	0.001	0.01
MW-5A	07/12/2000	6.7	138	0.1		0.0001		0.005	0.005	0.001	0.01
MW-5A	06/30/2001	7.3	164	0.1		0.0004		0.002	0.003	0.001	0.01
MW-5A	07/10/2002	7.6	137	0.1		0.0001		0.001	0.005	0.001	0.01
MW-5B	09/28/1989	7.7	208	0.1	0.005	0.001		0.01	0.02	0.01	0.01
MW-5B	07/25/1990	7.7	178	0.1	0.005	0.0003	0.02	0.009	0.02	0.002	0.03
MW-5B	08/22/1990	6.5	202	0.1	0.005	0.001	0.02	0.01	0.02	0.01	0.02
MW-5B	10/11/1990	7.3	211	0.1	0.005	0.001	0.02	0.01	0.02	0.01	0.02
MW-5B	07/11/1991	6.9	179	0.1	0.005	0.0003	0.02	0.002	0.02	0	0.01
MW-5B	10/01/1991	7.2	209	0.1	0.005	0.0003	0.02	0.004	0.02	0.002	0.02
MW-6	09/28/1989	3.5	455	3.9	0.05	0.014		0.21	0.37	0.02	0.55
MW-6	07/25/1990	3.7	445	1.4	0.044	0.0015	0.02	0.08	0.24	0.034	0.25
MW-6	08/21/1990	3.5	437	4.3	0.027	0.002	0.02	0.13	0.22	0.06	0.18
MW-6	10/11/1990	4.6	361	0.2	0.076	0.003	0.02	0.05	0.22	0.01	0.12
MW-6	07/11/1991	4.3	378	7.1	0.026	0.0014	0.02	0.17	0.34	0.039	0.88
MW-6	10/02/1991	5.5	332	0.4	0.063	0.0019	0.02	0.052	0.28	0.002	0.13
WQB-7 Human Health Standard				-	0.02	0.005	0.1	1.3	0.05	0.015	2.1

Notes: Shaded values exceed the groundwater standards
umhos/cm = micromhos per centimeter; s.u. = standard units

Spring data collected by Hydrometrics were analyzed in detail by MDEQ during the permitting process for CBMI's proposed New World Mine (MDEQ, 1996). This analysis was completed in part to attempt to predict mine drainage water quality if the proposed mine were permitted. Five of the springs in Miller Creek were included in a geochemical analysis of the data, with the concluding result of the analysis indicating that springs in Miller Creek belonged to one type of water (Type III), with water chemistry dominated by the ions calcium, bicarbonate, and sulfate. This groundwater type was found downgradient of the Miller Creek ore body, and contained low metal concentrations with a near neutral pH.

Durst (1999) performed another study of springs in Miller Creek for his Master of Science thesis. Durst measured flow, temperature, pH, and SC from 66 springs in the Miller Creek drainage. Spring measurements were collected on 12 different dates in 1996 and 1997. Springs were mapped and located using an altimeter, triangulation, and the USGS topographic map. Durst noted in his study that springs associated with bedrock formations accounted for 60% of the spring discharge in upper Miller Creek during mid-summer, and these springs continued to discharge through the summer and into November. Springs associated with surficial soil deposits (such as glacial till, colluvium, and rock glaciers) also contributed significantly to total spring discharge in the Miller Creek watershed. A third category of springs was iron-oxide (ferricrete) springs, which were many in the watershed but contributed little to overall spring discharge.

Springs were divided into groups based on association with geologic formations, lineaments (e.g. faults), and those of unknown origin. Springs associated with geologic formations tended to have higher SC

values than the other groups of springs. Four of the springs were found to discharge from adits or collapsed adits, and thirteen springs produced iron-staining on substrate below the spring discharge.

3.7 NATURAL RESOURCE RESTORATION ISSUES

Natural resource restoration issues that have been identified by the USDA-FS sponsored Natural Resource Working Group are included in this EE/CA for several reasons, including: 1) Roads associated with historic mining account for a considerable source of metals and sediment in the Miller Creek drainage; 2) The Miller Creek EE/CA is the final EE/CA prepared for the project that will address solid sources of metal contaminants; and 3) The Miller Creek EE/CA is a forum that allows public input and comment on restoration issues.

Two principal restoration issues have been identified by the Natural Resources Working Group, the impact of sediment derived from roads throughout the District on surface water quality, and damage to probable wetlands impacted by historical mining activities located in the Fisher Creek valley immediately below the Glengarry Mine portal. The identified impacts related to these restoration issues are described and characterized in this section along with proposed restoration actions. These activities are carried forward as ancillary activities to the Miller Creek alternatives presented in Section 7.0 of this report.

3.7.1 Roads as a Source of Sediment and Contamination

Large areas of known and potential acid production, and other large areas of anomalous metal concentrations in soils and bedrock were described previously (Section 3.3). Copper values in excess of 2,500 ppm (0.25 percent) were reported for select samples in these areas, resulting in a significant source of metals that could be carried in surface runoff. Contributions of detectable dissolved and suspended copper load are carried to surface water from these areas during both high and low flow, particularly in areas where soils have been disturbed by road building. In addition, other areas of known and potentially acid generating rock have been mapped in the District (**Figure 11**), with the potential for releasing acidity as these minerals oxidize, and increasing the solubility of metals in soils. Areas of known and potential acid production and other areas of anomalous metal concentration in soils and bedrock represent significant sources of contamination, which are often exacerbated by surface disturbances such as roads that expose these materials to ongoing erosion both on roadbeds and cut and fill slopes (**Figure 16**).

An unpublished report by the USDA-FS (Shovic, 2001) characterized roads within the District and adjacent areas of the Gallatin National Forest for reclamation purposes. The majority of roads occur in the Daisy Creek, Fisher Creek, Miller Creek, and Upper Soda Butte Creek drainages, with half of all roads occurring in the Fisher Creek and Miller Creek drainages (**Table 3-11**).

Water quality impacts in the district are directly related to the production of acidic solutions and consequent metal dissolution from sulfide-bearing rocks and soils. Some roadways pass through areas of metals-enriched soils or exposed and fractured acid-producing rock, and are in close proximity to creeks and streams (**Figure 16**). Roadway disturbances are typically not vegetated and are frequently disturbed by ongoing maintenance activities that are exacerbated by the highly erosive nature of the area. These conditions make them likely sources for sulfide-bearing and metals-contaminated sediment.

TABLE 3-11 ROAD LENGTH BY ROAD CLASS AND WATERSHED New World Response and Restoration Project Miller Creek Response Action EE/CA		
Watershed	Total Length of Roads (meters)	Percent of Total
Clark's Fork	354	0.3
Daisy	12,935	11.4
Fisher	32,767	28.9
Miller	27,119	23.9
Sheep	2,996	2.6
Soda Butte	36,444	32.2
Stillwater	558	0.5
West Rosebud	115	0.1
Total	113,288	100.0

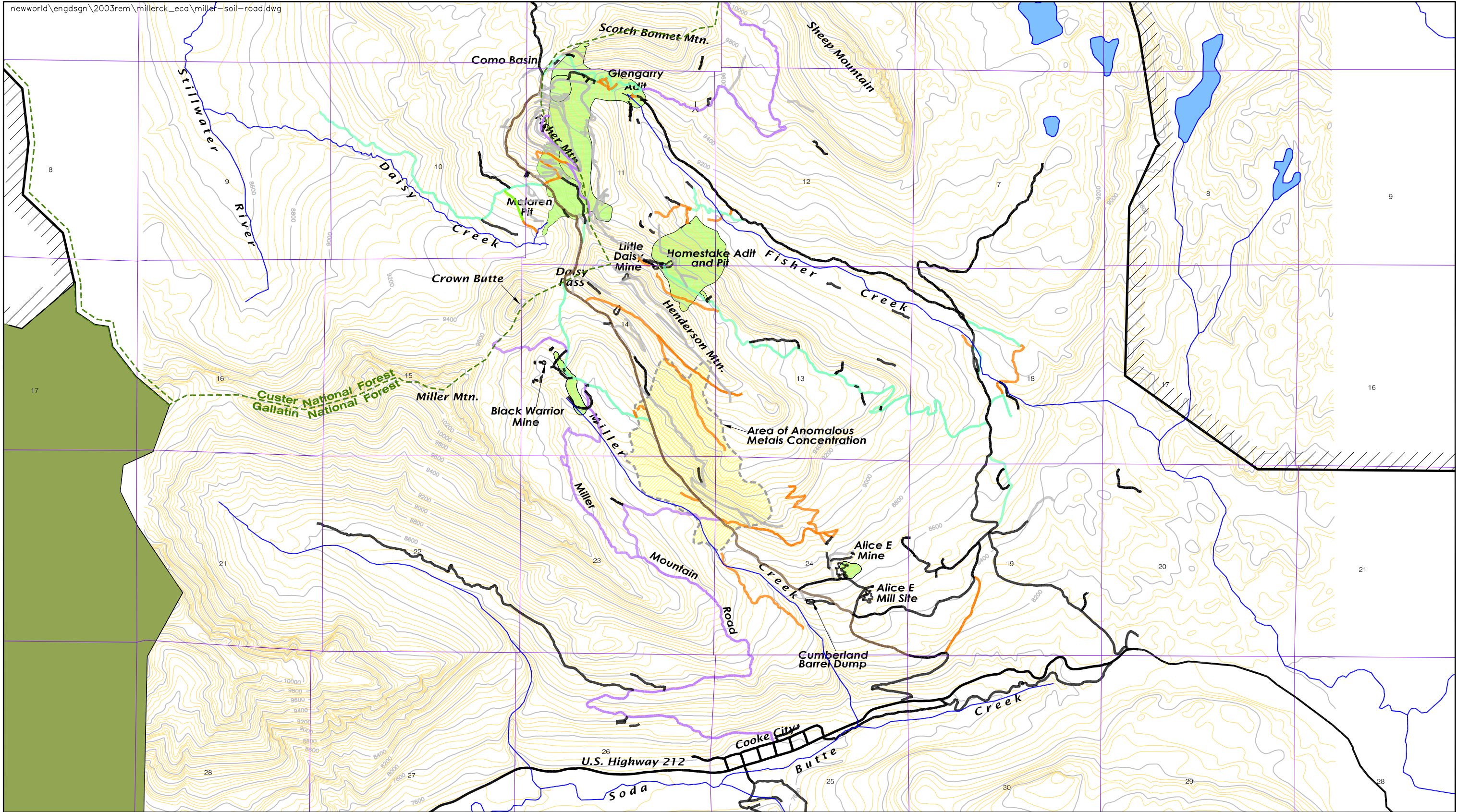
In addition, the steepness of some roads increases the severity of erosion and sedimentation. Grades of over 30% are locally present along some sections of 4-wheel drive roads and some major roadways have grades of as much as 9%. Sediment may also be generated from cut and fill slopes along roadways that often lack vegetation, and culverts that have historically received minimal maintenance.

Although this potential source of contamination is present throughout the District, its impact is locally overwhelmed by impacts from clearly identifiable mining-related contaminant sources such as mine waste dumps in drainages such as Fisher and Daisy Creeks. In the Miller Creek drainage, however, where mining impacts are less significant and much less extensive, sediment erosion and contaminant transport from roadway sources becomes relatively much more important. In the Miller Creek drainage in particular, metal contamination occurs almost exclusively during high water flow events, suggesting contaminants may be being carried in suspension in snowmelt waters that are eroding soils containing anomalously high metals concentrations.

As can be seen on **Figure 16**, long segments of roads in the Miller Creek watershed are in close proximity to the creek and also travel along source areas contaminated by metals and acidity. Portions of the roads in the Miller Creek drainage also have very steep slopes, including some grades of 9% on the main county road, which are also conducive to erosion. The Miller Creek watershed has approximately 27,000 meters of road, which accounts for nearly 25% of the total length of roads in the project area.

Since sediment loading from roads into streams constitutes a natural resource impact by the release of sediment and contaminants only indirectly related to historic mining on the District Property, the USDA-FS has decided to respond with restorative actions that would limit erosion from existing roadway disturbances. Five types of road rehabilitation actions are proposed:

- I) Road closure; including either recontouring or obliteration (ripping in place), followed by seed and fertilizer application, and installation of erosion blankets.



- 2) Drainage and turnpike construction in low-lying road sections. Spot surfacing. These roads would remain open. (Turnpike construction is a descriptive engineering term for roadwork where drainage relief is provided for standing water problems along low-lying areas.)
- 3) Restricted width use (spot drain and surface where needed for sediment control).
- 4) Road closed by institutional controls (barriers or gates) to all non-administrative travel.
- 5) These roads would remain open with improvements that would include drainage, constructing ditches, installing culverts and/or rock check dams or other sediment control structures. Cut and fill slopes would be revegetated.

In preparation for updating and modifying the Custer and Gallatin National Forest travel plans, which are currently underway, comments and reviews were received from personnel within the USDA-FS, Maxim, and various environmental groups concerning roadway use. The decision was made by the Natural Resource Working Group to apply the rehabilitation actions listed above to different segments of roads as mitigation for impacts to natural resources within the District.

In the USDA-FS evaluation of road reclamation, Shovic (2001) identified characteristics associated with roads in the project area that are considered important to evaluating their potential for future reclamation activities. These characteristics include road quality, present use, intensity of use, watershed location, ownership, present reclamation status, average road grade (slope), and the roadway's proximity to material with acid or metal production potential. These characteristics were taken into consideration and the segments of roads to be treated by each action were identified (**Figure 16**).

The total length of road assigned to each of the five rehabilitation categories was determined (**Table 3-12**). Under this scenario, 38% of road rehabilitation work would occur in the Miller Creek drainage while 16%, 27%, and 19% of the work would be performed in Daisy Creek, Fisher Creek, and Soda Butte Creek drainages, respectively. Less than 1% of the road rehabilitation work would occur in the Stillwater and West Rosebud drainages. Rehabilitation Action 1, road closure via recontouring or obliteration, would account for 25% of the work performed. Action 2, drain and leave open, would account for 30% of the total work. Actions 3 will primarily occur in the Daisy Creek, Fisher Creek, Miller Creek, and Soda Butte Creek drainages, amounting to 30% of the total road work. Action 4 will only be done in the Daisy Creek drainage, amounting to less than 1% of the work. The remaining rehabilitation work (15%) will be Action 5, drainage improvement on open roads.

The USDA-FS also modeled sediment loads from roadways and mine waste dumps in the district. The R1/R4 sediment model (Cline et. al., 1981) was used to predict the decrease in sediment loading resulting from road rehabilitation (Story, 2003). Model predictions indicate that complete implementation of the actions depicted in **Table 3-12** will result in a 4.5, 3.4, 3.6, and 3.2 ton/year decrease of sedimentation from roads in the Daisy Creek, Fisher Creek, Miller Creek, and Upper Soda Butte Creek watersheds, respectively (**Table 3-13**). These tonnages represent 11%, 5%, 13%, and 4% reductions in the total sediment loads in the Daisy Creek, Fisher Creek, Miller Creek, and Upper Soda Butte Creek watersheds, respectively. Similar load analysis for revegetation of mine waste dumps in these drainage basins results in an additional 12%, 16%, 1%, and 2% reduction, respectively, of sediment loads in the Daisy Creek, Fisher Creek, Miller Creek, and Upper Soda Butte Creek watersheds. Finally, if both road rehabilitation actions and mine waste revegetation takes place, total sediment loads can be reduced by 23%, 21%, 15%, and 5% in the Daisy Creek, Fisher Creek, Miller Creek, and Upper Soda Butte Creek watersheds, respectively.

TABLE 3-12
ROAD LENGTH BY REHABILITATION TYPE
New World District Response and Restoration Project
Miller Creek Response Action EE/CA

Road Rehab Type	Road Length (kilometers)						
	Daisy Creek	Fisher Creek	Miller Creek	Soda Butte Creek	Still-Water Creek	Rose Bud Creek	Total
1	0.938	3.317	6.328	0.916	0.0	0.036	11.535
2	2.702	5.559	1.634	3.025	0.087	0.0	13.007
3	1.070	3.324	5.225	4.100	0.0	0.079	13.798
4	0.305	0.0	0.0	0.0	0.0	0.0	0.305
5	2.100	0.080	4.139	0.389	0.0	0.0	6.708
Total	7.115	12.28	17.326	8.43	0.087	0.115	45.353

TABLE 3-13
SEDIMENT MODELING RESULTS BY DRAINAGE BASIN
New World District Response And Restoration Project
Miller Creek Response Action EE/CA

Sediment	Drainage Basin			
	Daisy	Fisher	Miller	Soda Butte
Existing Sediment Load				
Natural drainage basin derived sediment (tons/yr)	22.7	37.8	16.3	59.1
Road derived sediment (tons/yr)	13.3	16.4	8.9	23
Mining waste derived sediment (tons/yr)	7.8	11.3	2.1	1.3
Total sediment (tons/yr)	43.8	65.5	27.3	83.4
Increase in sediment over natural conditions (%)	93 %	73 %	68 %	41 %
Post-Treatment Sediment Load				
Road derived sediment (tons/yr)	8.8	13	5.3	19.8
Mining waste derived sediment (tons/yr)	2.4	0.8	1.7	0
Total road/mining waste sediment (tons/yr)	11.2	13.8	7.0	19.8
Road sediment decrease from total load (%)	11 %	5 %	13 %	4 %
Mining waste sediment decrease in total load (%)	12 %	16 %	1 %	2 %
Reduction in man-caused sediment load (%)	53 %	50 %	64 %	81 %
Total sediment (tons/yr)	33.9	51.6	23.3	78.9
Total sediment reduction (tons/yr)	9.9	13.9	4.0	4.5
Total sediment reduction (%)	22.6 %	21.2 %	15 %	5.4 %
Increase sediment over natural conditions (%)	49 %	37 %	43 %	33 %

Note: Table modified from Story (2003)

3.7.2 Glengarry Mine Wetland

The area immediately downgradient of the Glengarry mine portal is believed to have been in large part wetland prior to historic mining activities. In particular the area underlying the Glengarry waste rock dump and the poorly vegetated area to the south of the millsite along the southwest side of Fisher Creek (once the site of three tiered settling ponds), are each thought to have been likely sites for wetlands based on low-lying, near-stream topography and adjacent vegetation types. Lovering (1929) noted that groundwater-fed fen-type bogs were present in this location. The Glengarry waste rock dump is to be moved in conjunction with closure of the Glengarry mine and it is proposed that wetlands be reconstructed as part of natural resource restoration in these areas.

To construct the wetland, it is envisioned that, following removal of the Glengarry dump, the area will be excavated into native soil to allow for groundwater to recharge an area to the west of a reconstructed channel for Fisher Creek. The wetland may or may not have standing water, depending on the final ground contour. Groundwater will be the sole source of water flow into the wetland, and appropriate vegetation will be planted. The wetland will likely occupy the area of the former mine dump plus some disturbed areas immediately downstream. The area will likely be no greater than 0.5 hectare (1.2 acres).

3.8 CUMBERLAND/ LOWER MILLER CREEK DUMP SITE

The Cumberland dump site is located between the Daisy Pass Road and the lower portion of Miller Creek (**Figure 3**). This is not a mine waste dump; the dump contains trash and debris, some of which is mining related. Items included in this material are 18 empty, 17 kilogram, cyanide drums (labeled), a variety of empty 55-gallon drums (unlabeled), used assay crucibles, segments of wire rope, chain, tires, scrap metal, a dragline bucket, and miscellaneous metal and wood scrap material. Campers have used this site for a number of years, and there is also some household trash on the site. The area over which this debris is strewn is about 0.6 ha (1.5 acres), and although most of the debris lies some 50 meters (150 feet) from the stream, a few 55-gallon drums and a few tires are present along the stream banks.

3.9 SOURCES AND EVIDENCE FOR PRE-MINING ACID ROCK DRAINAGE

A number of pre-mining sources, some of which are introduced and described above, have been identified as probable natural occurrences of acid rock drainage (ARD) and metal loading to streams. Considerable evidence provides convincing support for the conclusion that many of these sources existed prior to mining. Absolute quantification of the amount of contamination attributable to these pre-mining sources is difficult, however, and has been the subject of considerable investigation (Runnells, 1992; Furniss and Hinman, 1998; Lovering, 1929). Probable natural background sources of ARD at New World include: metal-enriched, massive sulfide deposits; mineralized zones in bedrock; disseminated sulfides contained within very large masses of intrusive rocks; fracture and fault controlled mineralization; anomalous metal concentrations in native soils; groundwater migration through sulfide and metal-bearing bedrock units; transported and deposited metal-bearing sulfide sediments; chemical precipitates along tributary drainages and in over-bank sediments; ferricrete deposits; and, metal-enriched bogs. The mechanisms of natural ARD and metal loading to surface waters have been developed and discussed in detail in the McLaren Pit Response Action EECA (Maxim, 2001b) and in the Como Basin/Glengarry Adit/ Fisher Creek Response Action EECA (Maxim, 2002a), and these detailed discussions are not reproduced here.

What can be said of the Miller Creek drainage is that in spite of the fact that impacts to water quality appear to be minimal, regionally altered and mineralized bedrock are a significant potential source of

contamination. This altered and mineralized rock has been exposed to weathering at the surface since post-glacial times. In the Miller Creek drainage, this is evidenced by streambed and terrace deposits of ferricrete.

3.9.1 Ferricrete Deposits

Ferricrete deposits are alluvial, colluvial, or talus deposits that are cemented by iron-manganese-aluminum oxide and hydroxides. The cementing agent (hydroxides) dehydrates over time to form a well-lithified material that typically resembles an iron oxide or rust-cemented breccia. These deposits contain anomalous amounts of other metals that are associated with and adsorbed to or co-precipitated with the iron hydroxides. Ferricrete deposits have been, and continue to be deposited along the hydrologic gradient below the Miller Creek drainage, and elsewhere, wherever seeps and springs containing acidic and metal laden waters come to surface.

Active, historic, and ancient deposition of these chemical precipitates was described by T. S. Lovering, a geologist with the USGS, during field studies of the District conducted early in the last century (Lovering, 1929). Excerpted from that report is the following:

“Talus breccias cemented by limonite cover many acres near the headwaters of the Clarks Fork of the Yellowstone (Fisher Creek). Large pyritic deposits occur near by, and both surface and groundwater move from the sulfides to the breccias, where deposition of iron hydroxide is going on actively”, and “Talus and gravel have been thoroughly cemented by iron hydroxide in many places near Red Mountain (Fisher Mountain), and areas covering many acres may be found on its western and eastern flanks.”

Furniss and Hinman (1998) mapped ferricrete deposits in the District (**Figure 17**), which are relatively common in the upper reaches of the Fisher Creek and Daisy Creek, but also present in the upper Miller Creek drainage. In the course of their mapping, they locally identified logs and other organic debris contained in these ferricrete deposits. Organic materials were collected from these ferricrete deposits for radiocarbon dating.

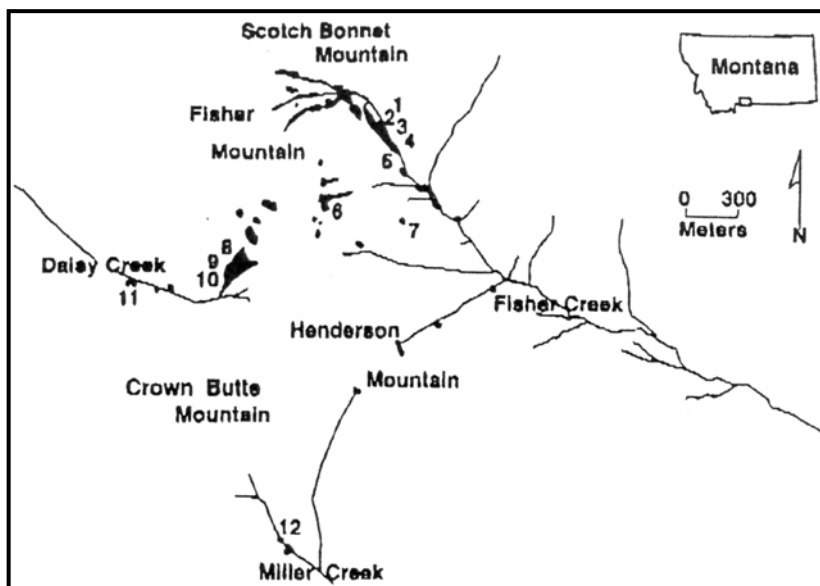


Figure 17. Location of mapped ferricrete deposits in the New World Mining District, Montana. Numbers indicate ferricrete sample locations with radiometric dates. Data from Furniss and Hinman (1998).

The dates reported from these samples range from 310 to 8,740 years before present (**Table 3-14**) (Furniss and Hinman, 1998), and a date of 2,050 years before present was determined from samples from upper Miller Creek. These dates are clear evidence that acid rock drainage and metal contamination was naturally occurring in each of these drainages, for approximately the last 9,000 years, long before historical mining activities.

TABLE 3-14 RADIOCARBON DATES FOR WOOD COLLECTED FROM FERRICRETE DEPOSITS IN THE NEW WORLD DISTRICT⁽¹⁾		
Sample Location⁽²⁾	Analytical Method⁽³⁾	Radiocarbon Date (years before present.)
1	B	6,800 ± 70
2	B	8,690 ± 80
3	B	5,810 ± 80
	B	6,920 ± 80
	B	7,030 ± 60
	B	7,170 ± 70
	B	7,170 ± 70
4	B	5,970 ± 150
	B	8,270 ± 70
5	B	30 ± 50
	B	60 ± 70
	B	100 ± 100
	B	550 ± 80
	B	890 ± 70
6	A	4,000 ± 60
7	B	1,670 ± 40
8	A	8,620 ± 60
9	B	310 ± 110
10	A	8,700 ± 50
	A	8,840 ± 50
11	A	6,490 ± 60
12	B	2,050 ± 50

(1) Data from Furniss and Hinman (1998)

(2) Radiocarbon dates in stratigraphic order where more than one date shown

(3) A = accelerator mass spectrometer; B = beta decay

Furniss and Hinman (1998) also chemically analyzed ancient and recent hydroxide cemented material and precipitates. The mean and range of compositions for several elements from each of these types of deposits are shown in **Table 3-15**. These data clearly indicate that not only were these ferricrete deposits formed long ago, but chemically they also contained anomalous metal concentrations, similar to those of modern chemical precipitates and ferricretes that form from ARD.

**TABLE 3-15
COMPOSITION OF IRON-OXYHYDROXIDES COLLECTED FROM ANCIENT AND
MODERN FERRICRETE DEPOSITS**

Element	Concentration (milligrams per gram)			
	Mean Ancient Samples	Mean Modern Samples	Range Ancient Samples	Range Modern Samples
Sulfur	6.90	32.00	0.80 – 17.40 (n=30)	1.60 – 49.80 (n=4)
Aluminum	10.80	63.00	0.33 – 55.80 (n=30)	0.750 – 141.0 (n=5)
Copper	2.58	5.80	0.08 – 12.60 (n=30)	0.075 – 21.1 (n=5)
Iron	239.00	236.00	21.8 – 446.0(n=30)	69.10 – 394.0 (n=5)
Lead	0.13	0.14	0.01 – 1.04 (n=17)	0.12 – 0.16 (n=3)
Magnesium	1.75	1.95	0.16 – 4.10 (n=11)	1.0 – 2.9 (n=2)
Manganese	1.10	0.27	0.01 – 8.01 (n=15)	0.06 – 0.64 (n=4)
Phosphorous	1.80	1.20	0.16 – 10.6 (n=25)	0.76 – 2.0 (n=4)
Potassium	1.24	3.20	0.23 – 2.6 (n=9)	1.3 – 5.0 (n=2)
Zinc	0.20	0.27	0.01 – 2.1 (n=25)	0.001 – 0.75 (n=4)

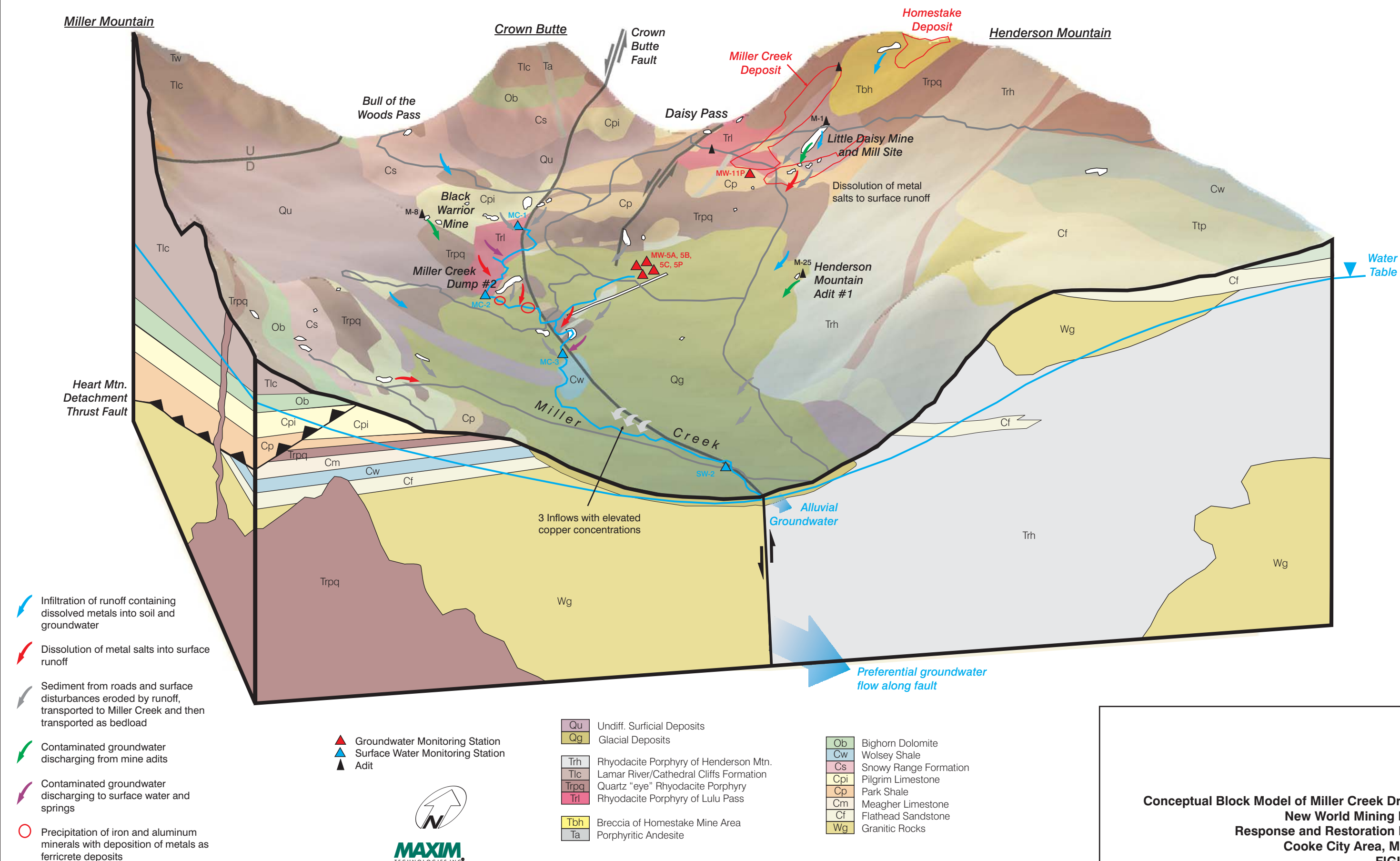
Notes: Data from Furniss and Hinman (1998)

Samples analyzed by strong acid leach digestion (nitric acid/hydrogen peroxide) and inductively coupled plasma emission spectrophotometry (ICP) (US EPA Method 3050)
(n = number of samples)

3.10 CONCEPTUAL MODEL

This section describes the current conceptual model for the Miller Creek watershed to provide a framework for reviewing impacts and remediation options. Discussed below are surface and groundwater flow, hydrogeology, and fate and transport of contaminants. **Figure 18** illustrates major elements of the conceptual model for the Miller Creek watershed.

The majority of precipitation within the area falls as snow in the fall, winter and spring, and as rain in early summer storms. Miller Creek is characterized by rapidly increasing flow rates and short periods of sustained flow during the snowmelt event. As much as 90 percent of Miller Creek's discharge volume occurs between early June and mid-July (**Figure 12**). Miller Creek and its tributaries receive base flow from groundwater seepage from unconsolidated sediments and fractured and faulted bedrock. Discharge from adits at the Little Daisy, Black Warrior, and Henderson Mountain No. 1 mine sites contribute varying but generally low flow volumes to Miller Creek.



Conceptual Block Model of Miller Creek Drainage
New World Mining District
Response and Restoration Project
Cooke City Area, Montana
FIGURE 18

Recharge to groundwater in the unconsolidated sediments comes from direct infiltration of snowmelt, runoff, and the discharge of water from bedrock fractures as springs adjacent to or beneath alluvial material. Shallow groundwater in colluvium discharges directly to Miller Creek. Recharge to bedrock occurs primarily as direct infiltration of snowmelt and runoff, particularly where fractures or faults are exposed at the surface, such as along the Crown Butte fault, which crosses Daisy Pass and trends southward along the axis of the Miller Creek valley.

The Miller Creek source area (**Figure 3, Table 3-1**) contains about 3,100 cubic meters (4,050 cubic yards) of wastes on District Property and a total of about 5,800 cubic meters (7,585 cubic yards) on District Property, non-District Property, and private land. In addition to these wastes, about 2,550 cubic meters (3,335 cubic yards) of historic mill tailings are present near the Alice E Millsite on non-District Property. These wastes account for a relatively minor portion (less than one percent) of the District's total mine waste.

No significant mining has taken place in the Miller Creek watershed since the late 1920's. Most mine wastes in the valley occur as small waste rock dumps associated with prospects, and small underground and open pit mines (**Figure 3**). These deposits are for the most part veins of quartz-sericite-pyrite with varying amounts of chalcopyrite, galena, sphalerite, and other base metal sulfides. The deposits were principally mined for gold and silver that can occur as native metals, or as inclusions within, or metal substitutions in, the crystal lattices of sulfide phases. In addition, lead was produced as a by-product of silver mining in some base metal deposits. When the ores of these deposits are exposed to weathering on mine waste dumps or to water flowing in underground workings, these sulfide minerals oxidize, releasing sulfate, iron, and acidity, which in turn increases the solubility of other metals. Surface water runoff and groundwater ultimately transport these metals to streams.

The principal mechanisms of transport of contaminants within the Miller Creek watershed and the District as a whole include the following (**Figure 18**):

- Physical erosion, transport, and deposition of materials by runoff and surface water.
- Dissolution of contaminants into surface runoff from primary mineralization or secondary sedimentary deposits.
- Infiltration of runoff containing dissolved metals into soil and groundwater.
- Movement of impacted water through open underground mine workings and improperly abandoned exploratory borings.
- Contaminated groundwater discharge into surface water.
- Contaminated surface water inflow to groundwater.
- Precipitation of iron and aluminum mineral phases with adsorption and deposition of trace metals as ferricrete deposits along Miller Creek's flow path.
- Scouring of secondary minerals and remobilization of metals.

Physical erosion of materials occurs where mine waste is exposed at the surface, such as at mine dumps at the mouth of the Little Daisy, Black Warrior, Alice E, and Miller Mountain mines, where metals-enriched soils are exposed on the flank of Henderson Mountain, and in disturbed roadbed and fill materials that crosscut these and other areas of metals enrichment. Surface runoff carries metal-laden

sediments to streams where they are entrained in the bedload of the creek. The mobility of the metals in streambed sediment is dependent on the chemistry of the water in the stream.

Metals will dissolve into surface water flowing across metal-laden material exposed at the surface. Metal bearing minerals in surficial materials are generally oxidized by exposure to water and atmospheric oxygen, which releases soluble metal salts that are highly mobile under acidic conditions. In addition, slope-wash from snowmelt or rain exposed to contaminated surface material will dissolve metals and transport them laterally to an adjacent stream or downward into underlying soil and groundwater. This occurs where sulfide-bearing rock is exposed at the surface (such as at the Little Daisy and Alice E Mines), in surficial deposits of mine wastes such as those scattered throughout the Miller Creek drainage basin, or from soils containing anomalously high metals concentrations such as those exposed on the flank of Henderson Mountain.

Groundwater can enter underground mines where the workings intersect bedrock fractures. The presence of atmospheric oxygen within the workings can enhance the dissolution of metals. Mine workings frequently act as conduits for groundwater, allowing water collected underground to discharge directly to surface water. This has occurred within the Little Daisy Mine, Black Warrior Mine, and in the Henderson Mountain Adit (M-25), as well as in association with other underground workings throughout the district.

Groundwater can transport dissolved contaminants to surface water at seeps and springs, as can be seen in modern and ancient deposits of ferricrete along the upper portion of Miller Creek, or anywhere else where groundwater directly discharges to the creek. Surface water can also transport metals to groundwater in losing reaches of streams.

All of the mechanisms described above can contribute to very localized degradation of surface and groundwater water quality in the immediate vicinity of the mines in the Miller Creek watershed,. However, in general, the surface water of Miller Creek has only been modestly affected by impacts from historic mining.

4.0 RISK EVALUATION

A streamlined risk evaluation process is used to assess threats to human health and the environment associated with exposure to mine wastes in Miller Creek. Risks are evaluated using site-specific chemical concentration data, applicable exposure scenarios, and pertinent risk-based cleanup guidelines or ecological criteria. This streamlined risk evaluation examines risks under existing site conditions, assuming no cleanup activities are performed at the site, and focuses on problems associated with mine waste present in the Miller Creek drainage in accordance with EPA guidance (EPA, 1993).

4.1 STREAMLINED HUMAN HEALTH RISK EVALUATION

Risk-based guidelines were developed for abandoned mine sites under a recreational scenario (Tetra Tech, 1995). A *User's Guide*, prepared for use by Montana's Mine Waste Cleanup Bureau (MWCB), summarizes the risk-based guidelines and describes how they were developed (Tetra-Tech, 1996). Although this risk evaluation method is not an EPA risk assessment process, it provides a basis to determine risks posed to humans using abandoned mine waste sites for recreational activities.

The streamlined human health risk evaluation involves four steps: (1) selection of contaminants of concern (COCs); (2) completion of an exposure assessment; (3) performance of a toxicity assessment; and (4) completion of risk characterization. These tasks are accomplished by evaluating available site data to select COCs, identifying applicable human populations and exposure routes, reviewing toxicity data, and characterizing overall risk by comparing COC concentrations in soil and surface water to previously derived, risk-based cleanup guidelines. Because there is no consumption of groundwater in the Miller Creek drainage, groundwater data were not evaluated with respect to human health risk (EPA, 1993).

4.1.1 Contaminants of Concern

COCs are contaminants that pose significant potential risks to human health or the environment. Surface water data collected at the site from 1989 through 2002 (**Table 3-4**) were evaluated to identify COCs for this media. Samples collected from mine waste sources in Miller Creek (**Table 3-2**) were evaluated to identify COCs for soil, and data from samples collected from stream sediments by Cleasby and Nimick (2002) were used to determine COCs for stream sediment in Miller Creek (**Table 3-9**).

Standard EPA criteria that must be collectively satisfied to establish a COC are the following: (1) the contaminant is associated with mining wastes present at the site; (2) has an average concentration at least three times average background levels; and (3) has been measured at concentrations above the detection limit in at least 20% of the samples analyzed. Based on these criteria, **Table 4-1** shows that lead and zinc were identified as contaminants of concern for mine waste. Contaminants in stream sediment include copper and lead.

For surface water risk, background data are not meaningful. Therefore, COCs were identified if average site concentrations exceeded the most restrictive water quality standard, the chronic aquatic standard for metallic contaminants. **Table 4-1** shows that average concentrations for chromium, dissolved copper, manganese, and zinc do not exceed the most restrictive water quality standard. Historically, arsenic has not been detected in surface water above practical quantification limits (Stanley and Maxim, 1998). Mean concentrations of aluminum, copper, iron, and lead at both Stations SW-2 and SW5 on Miller Creek exceed the chronic water quality standards and are, therefore, considered COCs. It should be noted though that the chronic aquatic standard for lead was only exceeded in three of the 44 samples collected at SW-2 and SW-5, and that seven of 44 samples (16%) exceeded the detection limit.

TABLE 4-1
IDENTIFICATION OF CONTAMINANTS OF CONCERN*
New World District Response and Restoration Project
Miller Creek Response Action

Contaminant	Surface Water		Mine Wastes		Stream Sediments	
	Exceeds Standard	20% Samples > Detection	> 3 Times Background	20% Samples > Detection	> 3 Times Background	20% Samples > Detection
Silver	--	--	No	No	No	Yes
Aluminum (tr)	Yes	Yes	--	--	--	--
Arsenic	--	--	No	Yes	No	Yes
Cadmium (tr)	No	No	No	Yes	No	Yes
Chromium	--	--	No	Yes	No	Yes
Copper (diss)	No	Yes	--	--	--	--
Copper (tr)	Yes	Yes	No	Yes	Yes	Yes
Iron (tr)	Yes	Yes	--	--	--	--
Manganese (tr)	No	No	--	--	--	--
Mercury			No	Yes		
Lead (tr)	Yes	No**	Yes	Yes	Yes	Yes
Zinc (tr)	No	Yes	Yes	Yes	No	Yes

Notes: Contaminants of concern shown as shaded cells

** Lead conservatively carried forward as COC although fewer than 20% of samples exceed the detection limit.

tr = total (for solids) or total recoverable (for surface water); diss = dissolved

However, the three exceedance values measured were large enough that, when averaged together with all of the other samples, the average value (0.0045 mg/L) exceeds the standard (0.0032 mg/L). Two of the samples that exceed the standards (SW-2 at 0.014 mg/L and SW-5 at 0.022 mg/L) occurred on the same sampling date (June 26, 1990), which is also coincident with the highest flow values ever recorded at each of these two stations (48.7 cfs and 90 cfs, respectively). The other lead exceedance value (0.042 mg/L) occurred at station SW-2 on June 5, 1991, also at a very high flow (38.7 cfs). It is likely that these elevated values represent water quality affected by suspended sediment during peak flow events. In order to be conservative with respect to metal contamination, lead is retained as a COC in surface water, although only 16% of the sample exceeded the detection limit. The only other COC for human health is copper.

Aluminum in surface water is not considered a risk to human health and will only be considered in the ecological risk portion of this evaluation. According to WQB-7 (MDEQ, 2002), the concentration of iron must not reach values that interfere with the uses specified in the standards. The secondary maximum contaminant level of 0.3 mg/L which is based on aesthetic properties such as taste, odor, and staining may be considered as guidance to determine the levels that will interfere with the specified uses. For risk evaluation purposes, iron data collected since 1999 (Table 3-4) in Miller Creek have been considerably below this value, so iron is not considered a contaminant of concern.

4.1.2 Exposure Assessment

An exposure assessment identifies potentially exposed human populations, exposure pathways, and typical exposure durations. Analytical results for soil and water samples are then used to estimate COC

concentrations at exposure points and the potential intake of contaminants. Current human exposure to site-related contaminants in soil and surface water is via seasonal recreational activities on and near the dump sites in Miller Creek. There is currently no residential use of District Property.

The risk evaluation assumed four types of recreation populations: fishermen, hunters, gold panners/rock-hounds, and ATV/motorcycle riders. Evaluated exposure pathways included soil and water ingestion, dermal contact, dust inhalation, and fish consumption. The assessment assumed a moderate to high level of recreational use. The types of activities, exposure pathways, and use levels considered in the recreational scenario are consistent with current recreational uses of District Property. Consequently, the recreational scenario exposure assessment is comparable and applicable to current human exposure at the site.

4.1.3 Toxicity Assessment

A toxicity assessment provides information on the potential for COCs to cause carcinogenic and non-carcinogenic adverse health effects. Toxicity values for COCs are derived from dose-response evaluations performed by EPA. Sources of toxicity data include EPA's Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Health Effects Assessment Summary Tables (HEAST), and EPA criteria documents. Individual toxicity profiles for each COC are provided in the reference document (Tetra-Tech, 1996).

4.1.4 Risk Characterization

Findings of the recreational scenario exposure assessment were combined with toxicity data for the COCs to characterize health risks posed to each population through various exposure routes (Tetra Tech, 1995, 1996). The maximum calculated risks were for: (1) a rock-hound/gold panner (soil contact and surface water ingestion); (2) a fisherman (soil contact, surface water ingestion, and fish consumption); and (3) an ATV/motorcycle rider (soil contact, dust inhalation).

To ensure the protection of the majority of recreational visitors, MWCB also developed a set of conservative, risk-based cleanup guidelines for abandoned mine sites based on the lowest cleanup concentration calculated for the various types of exposure and the possibility of multiple exposure routes. The guidelines thus account for visitors participating in several activities and metals exposure routes from both soil and surface water. The conservative, risk-based cleanup guidelines for soil and water are presented in **Tables 4-2 and 4-3**. The guidelines for each medium are based on a hazard quotient (HQ) of 1.0, where a HQ is the ratio of a chemical exposure concentration to a reference dose that represents a threshold level for human health effects. An HQ greater than 1.0 may cause adverse health effects.

Potential health risks for the site are characterized by comparing the risk-based concentrations in **Tables 4-2 and 4-3** to site-specific soil and surface water quality data. The solid media chemistry data used for the calculation of hazard quotients in **Table 4-2**, are the average concentrations presented in **Table 3-2 and 3-4**. The calculation of the hazard quotient in **Table 4-2** was performed using the greater of the two media values for each constituent. The water quality data used for the calculation of hazard quotients in **Table 4-3** are the average concentrations shown in **Table 3-4** at Station SW-2, which is on Miller Creek, below the Miller Mountain road crossing. The total hazard quotient calculated in **Table 4-4** includes the soil ingestion/dust inhalation and water ingestion/fish ingestion routes.

TABLE 4-2
Hazard Quotients For Recreational Visitors Exposed To Soil Ingestion And Dust Inhalation
New World Mining District Response and Restoration Project
Miller Creek Response Action

Contaminant of Concern	Average Waste Rock Concentration (mg/kg) ⁽¹⁾	Average Stream Sediment Concentration (mg/kg) ⁽²⁾	Soil Ingestion/Dust Inhalation Guideline (mg/kg) ⁽³⁾	Hazard Quotient ⁽⁴⁾
Arsenic	87.4	4	700	0.12
Cadmium	19.7	3	19,500	0.001
Chromium	12.2	9	735,000 (2,920) ⁽⁵⁾	0.0002
Copper	402	252	27,100	0.02
Lead	4,747	443	1,100	4.3
Zinc	943	0.5	220,000	0.004

- Notes: (1) Data from Table 3-2; mg/kg = milligrams/kilogram.
 (2) Data from Cleasby and Nimick 2002) and Table 3-9 (this report).
 (3) Guidelines recalculated from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 0.5 or an increased cancer risk of 5×10^{-4} .
 (4) Hazard quotient calculated for the greater of the waste rock or in-stream sediment concentration.
 (5) Guideline based on chromium III risk and chromium VI risk (in parenthesis).

TABLE 4-3
Hazard Quotients for Recreational Visitors Exposed to Water and Fish Ingestion
New World Mining District Response and Restoration Project
Miller Creek Response Action

Contaminant of Concern	Average Water Concentration (micrograms/liter) ⁽¹⁾	Water and Fish Ingestion Guideline (micrograms/liter) ⁽²⁾	Hazard Quotient
Arsenic	5 ⁽³⁾	65	0.08
Cadmium	0.3	66.5	0.004
Chromium	20 ⁽⁴⁾	100,246 ⁽⁵⁾	0.0002
Copper	27	472	0.06
Lead	5	47.1	0.1
Zinc	30	17.2	1.7

- Notes: (1) Data from Table 3-4 - mean concentration at SW-2 for period 1989-2001
 (2) Guidelines recalculated from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 0.5 or an increased cancer risk of 5×10^{-4} .
 (3) All As values below detection at 5 micrograms/liter.
 (4) All Cr values below detection at 20 micrograms/liter.
 (5) Guideline based on chromium III risk.

TABLE 4-4
Total Hazard Quotients (HQ) for the Recreational Land Use Scenario
New World Mining District Response and Restoration Project
Miller Creek Response Action

Contaminant of Concern	Soil Ingestion/Dust Inhalation HQ	Water Ingestion/Fish Ingestion HQ	Total HQ for Contaminant
Arsenic	0.12	0.08	0.2
Cadmium	0.001	0.003	0.004
Chromium	0.0002*	0.0002*	0.0004
Copper	0.02	0.06	0.08
Lead	4.3	0.1	4.4
Zinc	0.004	1.7	1.7

Notes: * Assumes risk associated with chromium VI

The total hazard quotients for arsenic, cadmium, chromium, and copper do not exceed 1.0, which indicates that these COCs do not pose a human health risk in Miller Creek. The total hazard quotient for lead and zinc is 4.4 and 1.7 respectively. Lead in the soil is responsible for the potential lead risk to human health by both the soil ingestion and dust inhalation pathways, whereas, zinc in surface water poses a potential human health risk based on water and fish ingestion pathways. In this assessment, almost the entire risk of zinc in Miller Creek is posed by ingestion of fish taken from this stream by recreationists. Because there are currently no fish in Miller Creek at Station SW-2 or SW-5, where the risk calculation was applied, the risk of exposure to zinc in Miller Creek is probably not a concern. Because of this, zinc will not be carried forward as a human health risk.

4.2 STREAMLINED ECOLOGICAL RISK EVALUATION

The streamlined ecological risk evaluation was completed to assess the potential risk that mine wastes pose to plants and animals at the site. The evaluation was performed by comparing concentrations of COCs in surface water, sediment, and soil with ecological criteria and standards available in toxicity literature and risk-based EPA guidance. The key guidance documents used were EPA's *Ecological Risk Assessment Guidance for Superfund* (EPA, 1997), *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual* (EPA, 1989a), and *Ecological Assessment of Hazardous Waste Site* (EPA, 1989b). Because there are no site-specific ecological risk data available, this streamlined ecological risk evaluation, although executed in a quantitative manner, is only intended to be qualitative.

Because this streamlined ecological risk evaluation focuses on COCs, no evaluation was done with respect to the physical habitat present in the District nor was an assessment made toward how other factors may have affected aquatic or terrestrial populations. The presence or absence of appropriate habitat for animals, spawning beds for fish, or the health of wetlands and riparian areas, while it may affect the presence, diversity, or nature of aquatic and terrestrial populations, are not considered under the non-time-critical removal process evaluation of risk. A use attainability study is the mechanism that would assess the nature of the contamination in conjunction with other habitat factors such as those mentioned above.

The streamlined ecological risk evaluation, like the human health risk evaluation, estimates the effects of taking no action at the site and involves four steps: 1) identification of COCs; 2) exposure assessment;

3) ecological effects assessment; and 4) risk characterization. These steps are completed by evaluating currently available site data to select the COCs, identifying species and exposure routes of concern, assessing ecological toxicity of the COCs, and characterizing overall risk by integrating the results of the exposure and toxicity assessments.

4.2.1 Contaminants of Concern

COCs at the site were identified in Table 4-1 as aluminum, copper, iron, lead, and zinc. Each of these contaminants has the potential to pose ecological risks.

4.2.2 Exposure Assessment

Two groups of ecological receptors have been identified as potentially being affected by site contamination. The first group includes aquatic life and wetlands in Miller Creek located downgradient of the source areas. These receptors are of concern because Miller Creek provides habitat for aquatic organisms, and although unlikely, Miller Creek may contain spawning areas for fish migrating from Soda Butte Creek. Wetlands are of concern because they typically support a diverse ecological community. The second group of receptors is native terrestrial plants at the site whose ability to grow in soil or mine waste is limited by relatively high concentrations of certain metals and low pH. Potentially adverse exposures of elevated metals and low pH media to aquatic life and terrestrial plants can be quasi-quantitatively assessed by comparing site-specific surface water, sediment, and soil data to toxicity-based criteria and standards for the respective media. Exposure pathways for aquatic life include: 1) direct exposure of aquatic organisms to metals in surface water that exceed toxicity thresholds; 2) exposure of aquatic organisms (e.g., insect larvae, fish embryos) to sediment pore water that is toxic due to contaminants in the sediments; and 3) ingestion of aquatic species (e.g., insects) that have accumulated contaminants by predators to the extent that they are toxic to predators (e.g., fish). Native terrestrial plants could be exposed to elevated concentrations of metals in soil or mine wastes at the site resulting in phytotoxic effects.

4.2.3 Ecological Effects Assessment

The COCs are known to have toxic effects on plants and animals (EPA, 1986; Long and Morgan, 1991; Kabata-Pendias and Pendias, 1992). No ecological effects data have been collected from the site, and no site-specific toxicity tests have been performed. As a result, this streamlined risk evaluation assesses potential ecological effects using existing and proposed ecological criteria and guidelines. The guidelines used to evaluate ecological risks from surface water, sediment, and phytotoxic soils at the site are listed in **Table 4-5**.

Surface water criteria are the Chronic Aquatic Life Standards promulgated by the State of Montana (MDEQ, 2002). Criteria for chromium (III), copper, lead, and zinc are calculated as a function of water hardness while aluminum, arsenic, and iron criteria are fixed numerical standards. The average hardness for Miller Creek is 83 mg/L, so this value was used for calculating the applicable hardness based standards. Sediment guidelines consist of Effect Range-Median (ER-M) values generated from the library of national fresh water and marine sediment toxicity information (Long and Morgan, 1991). Guidelines for soil phytotoxicity are from Kabata-Pendias and Pendias (1992). The availability of contaminants to plants and the potential for plant toxicity depends on many factors including soil pH, soil texture, nutrients, and plant species. Applicable guidelines are currently not available for aluminum, chromium, and iron in sediment and soil.

TABLE 4-5
Ecological Assessment Guidelines
New World Mining District Response and Restoration Project
Miller Creek Response Action

Contaminant	Surface Water ⁽¹⁾ (micrograms/liter)	Sediment ⁽²⁾ (milligrams/kilogram)	Phytotoxic Soil ⁽³⁾ (milligrams/kilogram)
Aluminum	87	--	--
Arsenic	150	85	15-50
Cadmium	0.18 ⁽⁴⁾	9	3-8
Chromium (as III)	86 ⁽⁴⁾	--	--
Copper	8 ⁽⁴⁾	390	60-125
Iron	1,000	--	--
Lead	2.5 ⁽⁴⁾	110	100-400
Zinc	67 ⁽⁴⁾	270	70-400

Notes: (1) Chronic aquatic life standards from WQB-7, Montana Numeric Water Quality Standards (MDEQ, 2002).
(2) Effect Range - Median from Long and Morgan (1991).
(3) Concentration ranges from Kabata-Pendias and Pendias (1992).
(4) Chronic standard at total hardness of 83 mg/L (MDEQ, 2002).
-- Criteria currently not available

4.2.4 Risk Characterization

This section integrates the ecological exposure and ecological effects assessments to provide a screening level estimate of potential adverse ecological impacts to aquatic life and native terrestrial plants. This was accomplished by calculating ecological-impact quotients (EQs), which are analogous to the HQs calculated for human exposures. Site-specific surface water and soil data used in this evaluation are summarized in **Tables 3-2, 3-4, and 3-9**. Mean concentrations are reported for surface water samples that were collected and analyzed between 1989 and 2002. The EQs were generated for each COC in surface water by dividing the mean concentrations of Station(s) SW-2 and SW-5 in Miller Creek (**Table 3-4**) by the chronic water quality criteria (**Table 4-5**). For soils, dividing the average values from **Table 3-2** by the phytotoxic soil values in **Table 4-5** generates EQs. Adverse ecological impacts may occur if an EQ value is equal to or greater than 1.0. Results of the EQ calculations are presented in **Table 4-6** and are discussed below.

4.2.4.1 SURFACE WATER - AQUATIC LIFE

For this scenario, surface water quality data are compared to chronic aquatic life criteria. This comparison is limited because EPA water quality criteria are not species-specific but were developed to protect 95 percent of the species tested and may not protect the most sensitive species, which may or may not be present in Miller Creek. In addition, toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The calculated EQ values indicate the potential for adverse aquatic life impacts (EQs greater than 1.0) for aluminum, cadmium, copper, and lead in surface water (**Table 4-6**).

TABLE 4-6
ECOLOGICAL IMPACT QUOTIENTS (EQ)
New World Mining District Response and Restoration Project
Miller Creek Response Action

Contaminant	Surface Water		Sediment		Phytotoxic Soil ⁽¹⁾		Total EQ
	Avg. Conc. ug/l ⁽²⁾ (µg/liter)	EQ	Avg. Conc mg/kg ⁽²⁾ (mg/kg)	EQ	Avg. Conc. ⁽²⁾ (mg/kg)	EQ	
Aluminum	300	3.4	--	--	--	--	3.4
Arsenic	5 ⁽³⁾	0.03	4	0.05	87.4	1.8	1.9
Cadmium	0.2	1.3	3	0.3	19.7	2.5	4.1
Chromium	20 ⁽⁴⁾	0.02	9	--	12.2	--	0.02
Copper	27	5.2	252	0.7	402	3.2	9.1
Iron	450	0.5	--	--	--	--	0.5
Lead	5	1.6	443	4	4,747	11.9	17.5
Zinc	30	0.5	0.5	0.002	943	2.4	2.9

Note: (1) Based on the high range of average concentration in Table 4-5

(2) Concentration from Tables 3-2, 3-4, and 3-9.

(3) Average concentration of arsenic assumed at 5 mg/L.

(4) Average concentration of chromium assumed at 20 mg/L.

-- Not calculated or not detected, toxicity data unavailable

µg/L = micrograms per liter; mg/kg = milligrams per kilogram; Avg. Conc. = average concentration

4.2.4.2 SEDIMENT - AQUATIC LIFE

Stream sediment concentration data are compared to sediment ER-M values determined by Long and Morgan (1991). This comparison is not definitive because sediment quality values are preliminary and are not species-specific. The guidelines represent sediment toxicity to the most sensitive species, which may or may not be present in Miller Creek, and toxicity to the most sensitive species may not preclude a healthy aquatic community. There are no site data for aluminum or iron in sediment. EQ values in **Table 4-6** indicate the potential for adverse impacts to aquatic life from lead in stream sediment.

4.2.4.3 SOIL PHYTOTOXICITY - NATIVE TERRESTRIAL PLANTS

Soil concentration data are compared to the higher values in the range of phytotoxicity guidelines. This comparison is limited because phytotoxicity ranges are not species-specific and thus represent toxicity to species that may or may not be present at the site. Additionally, other characteristics of waste materials, such as soil pH, texture, or nutrient deficiencies, may limit growth of terrestrial plants directly, or in combination with substrate toxicity. EQ values in **Table 4-6** indicate the potential for impacts to terrestrial plant communities due to arsenic, cadmium, copper, lead, and zinc in mine waste soils at the site. There are no site data for aluminum or iron in soil or waste rock. Although no data are available to document the release of these metals from mine waste and the subsequent uptake by vegetation, it is likely that a phytotoxic effect is occurring due to low pH. Low pH increases the mobility and bioavailability of metals except for arsenic, which is more mobile at more neutral pH levels.

In summary, most of the ecological risk at this site is in the surface water environment with the contaminants of greatest concern being aluminum, cadmium, copper, and lead. In addition, lead is the only contaminant of concern to aquatic life in stream sediments. Arsenic, cadmium, copper, lead, and zinc appear to be phytotoxic in mine waste soils.

5.0 RESPONSE ACTION SCOPE, GOALS, AND OBJECTIVES

The risk evaluation demonstrated that of the metals present in Miller Creek only lead is a contaminant of concern that poses a significant risk to human health related to dust ingestion and inhalation. Lead is however, only present in significant amounts in three waste rock dumps in the in Miller Creek drainage, only one of which, the Black Warrior dump, is located on District Property. Environmental risks associated with mine dumps appear in surface water and groundwater due to migration of contaminants from the mine dumps. These contaminants (aluminum, cadmium, copper, and lead) present ecological risks to aquatic life that are present in surface water. Lead, is the only contaminant in stream sediment that present risks to aquatic life. Phytotoxicity is a concern in mine waste due to excessive arsenic, cadmium, copper, lead, and zinc concentrations and low pH values.

This section of the EE/CA presents the scope of the Miller Creek Response Action and Removal Action Objectives (RAOs) to meet project goals and applicable or relevant and appropriate requirements (ARARs).

5.1 SCOPE OF THE RESPONSE ACTION

The scope of this response action is directed at eliminating or reducing uncontrolled releases of metals from mining-related sources in Miller Creek. Mining-related sources in the Miller Creek drainage include mine waste dumps at 47 sites (**Figure 3 and Table 3-1**), including the largest dumps at the Black Warrior (MCSI-96-2), Little Daisy Mine (MCSI-96-6), Little Daisy Millsite (MCSI-96-7-1 and 7-2), and Miller Creek Dump No. 2 (MCSI-96-1). Adit discharges occur at the Little Daisy, Black Warrior, and Henderson Mountain No. 1 (MCSI-00-103) adits. Cumulatively, mine waste in the various Miller Creek sites on District Property consists of about 3,100 cubic meters (4,050 cubic yards) of waste rock over a cumulative area of 1.1 hectares (2.7 acres). Metals loading investigations by Cleasby and Nimick (2002) and this report indicate that two distinct surface water sources in upper Miller Creek (the Black Warrior Mine, and the anomalous metal-rich soils source on Henderson Mountain that is associated with roads) likely supply the majority of the contaminant sediment load and dissolved metals to the creek.

By addressing releases to surface and groundwater from metals-enriched mine wastes and other sediment sources some reduction in contaminant concentrations are expected in surface water, groundwater, and new stream sediment accumulations as a result of removing or controlling these primary sources of mining-related metals contamination in Miller Creek. However, this response action does not directly address existing groundwater contamination, as source controls are expected to address only mining-related surface water impacts.

This response action does not address mine discharges located in the Miller Creek watershed. Because source control of mine wastes is considered to be a first step in attempting to reduce contaminant loading, options needed to treat discharges will be considered further in a subsequent response action EE/CA. In a separate study by the USDA-FS (Unifield, 2000), construction and operation of passive and active water treatment systems would be difficult and expensive. Passive treatment systems are less expensive than active treatment systems, but large flow variations and low water temperatures raise uncertainties relative to effectiveness and maintenance requirements.

5.2 REMOVAL ACTION OBJECTIVES

As outlined in the Overall Project Work Plan (Maxim, 1999b), the overall goals for the response and restoration project are: 1) assure the achievement of the highest and best water quality practicably

attainable on District Property, considering the natural geology, hydrology, and background conditions in the District; and 2) mitigate environmental impacts that are a result of historic mining. Based on the risk evaluation, the primary goal of the Miller Creek Response Action is to protect the environment by reducing the migration of contaminants into the environment.

The overall scope of the project is described in the Consent Decree (pp. 12-13, §VII.7(a)), which directs the project work to address the following:

- Releases or threats of release of hazardous substances, pollutants or contaminants that are related to District Property.
- Natural resources lost as a result of, or injured or destroyed by, releases or threats of release of hazardous substances, pollutants or contaminants that are released to District Property.
- Conditions affecting water quality and natural resources in Miller Creek, Fisher Creek, and Daisy Creek and their tributaries.

The Overall Project Work Plan (Maxim, 1999b) identifies 11 objectives to achieve project goals. The plan also recommends supplementing those objectives to correspond to response actions proposed for a given year. Project specific RAOs are:

- Minimize phytotoxicity resulting from high concentrations of copper and low pH in mine waste dumps.
- Prevent soluble contaminants or contaminated solid materials from migrating into adjacent drainages to the extent practicable.
- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or metals contamination to adjacent surface water and groundwater to the extent practicable.
- Prevent potential exposure through the food chain to metal contaminants from acid discharges and mine waste, to the extent practicable.
- Prevent or limit future releases and mitigate the environmental effect of past releases of hazardous substances, pollutants or contaminants.
- Comply with ARARs to the extent practicable, considering the exigencies of the circumstances.
- Take into consideration the desirability of preserving the existing undeveloped character of the District and surrounding area when selecting response and restoration actions.

5.3 ARAR-BASED RESPONSE GOALS

Response action goals are primarily contaminant-based concentrations that are set by federal or state laws and regulations. For this project overall, the primary contaminant-specific ARARs apply to groundwater and surface water. There are no contaminant-specific ARARs for soil media. A preliminary list of ARARs is presented in Appendix B. The USDA-FS will issue final ARARs in the Miller Creek Action Memorandum, which documents the decision involved with the selection of the preferred response alternative.

5.3.1 Surface Water

Aquatic life standards and human health standards are common ARARs for surface water. Generally, the more stringent of the two standards is identified as the ARAR-based reclamation goal. Because the aquatic life standards are more stringent than the human health standards for COCs, and ecological risks predominate at this site, aquatic standards represent the surface water ARARs for this site. These goals are presented in **Table 5-1**. Hardness in Miller Creek ranges from 47 to 112 mg/L at stations SW-2 and SW-5; the average hardness value is 83 mg/L. Those goals that are hardness dependent have been calculated based on a hardness of 83 mg/L. Enforcement of cleanup goals may be executed at specific water quality stations, in which case the cleanup standard for the hardness dependent contaminants should be calculated based on the hardness at those specific stations.

TABLE 5-1 ARAR-BASED RECLAMATION GOALS FOR SURFACE WATER New World Mining District Response and Restoration Project Miller Creek Response Action						
	Total Recoverable Metals (micrograms/liter) ⁽¹⁾					
	Aluminum	Chromium	Copper	Iron	Lead	Zinc
Goal	87	74	8	300	2.5	102

Notes: (1) Standards are in terms of total recoverable concentrations. Hardness based criteria are calculated for hardness = 83 milligrams/liter.

CBMI, with the support of the USDA-FS, petitioned the State of Montana Board of Environmental Review (Board) for temporary modification of water quality standards for certain stream segments in the District. The temporary standards are necessary so that improvements to water quality may be achieved by implementation of the response and restoration project. The Board approved a rule allowing temporary standards on specific reaches of Fisher Creek, Daisy Creek, and the headwaters of the Stillwater River on June 4, 1999. No temporary standards have been established for Miller Creek.

5.3.2 Groundwater

ARAR-based reclamation goals for groundwater are Montana Human Health Standards. Using these standards, ARAR-based goals for COCs in groundwater are shown in **Table 5-2**. Site-specific groundwater quality data are available for the District, and average dissolved concentrations of cadmium, copper, iron, lead, manganese, and zinc exceed these standards in one well at the Alice E Mine, which is located on private, non-District property.

5.4 SOIL CLEANUP GUIDELINES

As presented in Section 4.1, lead in the Black Warrior waste rock dump is the only human health risk associated with mine wastes on District Property in Miller Creek. Recreational cleanup goals for solid mine wastes have been adopted by MDEQ in the form of cleanup guidelines. Cleanup guidelines for COCs in the District are listed in **Table 5-3**.

TABLE 5-2
ARAR-BASED RECLAMATION GOALS FOR GROUNDWATER
New World Mining District Response and Restoration Project
Miller Creek Response Action

Chemical	Type ⁽¹⁾	Concentration (µg/L)
Arsenic	HHS (MCL)	20 (50)
Cadmium	HHS/MCL	5
Copper	HHS/MCL	1,300
Iron	MCL	300 ⁽²⁾
Lead	HHS/MCL	15
Manganese	MCL	50 ⁽²⁾
Zinc	HHS (MCL)	2,000 (5,000)

Notes: (1) HHS = Human Health Standard (MDEQ, 2002); MCL = Maximum Contaminant Level (EPA, 1996)

(2) Secondary standard for taste, odor, color.

µg/L = micrograms per liter

TABLE 5-3
CLEANUP GUIDELINES FOR MINE WASTE
New World Mining District Response and Restoration Project
Miller Creek Response Action

	Total Metals (milligrams/kilogram) ⁽¹⁾				
	Arsenic	Cadmium	Copper	Lead	Zinc
Human Health Guideline ⁽¹⁾	700	19,500	27,100	1,100	220,000
Reclamation Criteria ⁽²⁾	<30	<4	<100	<100	<250
Phytotoxicity Guideline ⁽³⁾	15-50	3-8	60-125	100-400	70-400

Notes: (1) Guidelines recalculated from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 0.5 or an increased cancer risk of 5×10^{-5} for the recreational visitor scenario.

(2) Criteria used for backfill materials at the Silver Bow Creek/Butte Area Streamside Tailings Operable Unit Remedial Action (ARCO, 1997).

(3) Concentration ranges from Kabata-Pendias (1992).

Ecological risk from waste dumps included in the Miller Creek Response Action is likely due to arsenic, cadmium, copper, lead, and zinc phytotoxicity. Because high metals concentrations in conjunction with low soil pH limit plant establishment on waste dumps, other criteria could apply to soil cleanup in the District. Reclamation criteria have been adopted for the Remedial Action underway on the Streamside Tailings Operable Unit near Butte, Montana. These criteria are also listed in **Table 5-3** along with phytotoxicity data from the literature. Finally, in lieu of removing metals from the soil, amending the soil to neutralize potential acid generation may reduce phytotoxicity without reducing metals concentrations. Soil cleanup guidelines should be balanced with the goals for the response project rather than used as absolute numerical criteria.

6.0 SCREENING AND DEVELOPMENT OF RESPONSE ALTERNATIVES

The description of the source, nature, and extent of contamination (Section 3.0), the conceptual model that portrays contaminant sources, release mechanisms, and exposure pathways (Section 3.10), and the RAOs developed for this phase of the project (Section 5.0) provide the basis for screening and development of response alternatives for mine waste dumps located in Miller Creek. The process presented in this section follows EPA guidance for non-time-critical removal actions (EPA, 1993) by first identifying potential response technologies and process options, screening these options through consideration of practical applications of the technologies to the scope of the removal action, and then assembling the remaining technologies and options into response alternatives.

6.1 RESPONSE TECHNOLOGY AND PROCESS OPTION SCREENING

The purpose of identifying and screening technology types and process options is to eliminate those technologies that are obviously unfeasible or ineffective, while retaining potentially effective options. General response actions and process options are specifically applied to the mitigation of contaminant release from mine waste dump sources in the Miller Creek watershed. No evaluation was conducted for technologies that directly treat contaminated groundwater or transported, contaminated stream sediments, as these environmental media may be addressed in future response actions. Addressing environmental impacts associated with mine waste dumps and the adit discharge presumes that some reduction in contaminant concentrations will occur in surface water, groundwater, and newly transported stream sediment as a result of removing or controlling these sources of contamination. Improvements in surface water and groundwater quality are expected to result from implementation of all of the other response actions; however, the absolute amount of improvement is difficult to quantify and is expected to be quite variable between specific response actions.

General response actions potentially capable of achieving RAOs and goals for Miller Creek are screened for applicability in **Table 6-1**. Response actions include no action, institutional controls, engineering controls, excavation and treatment, in-situ treatment, and migration treatment. The general response actions, technology types, and process options are discussed in text following the table. Screening comments are found in **Table 6-1**, and the logic and reasons for removing technologies or process options by screening are also discussed in the text. Technologies and options retained for alternative development are shaded in **Table 6-1**.

6.1.1 No Action

No action involves no further response or monitoring. No action is generally used as a baseline against which other response options are compared so **the no action alternative is retained** for detailed analysis.

6.1.2 Institutional Controls

Institutional controls are used to restrict or control access to or use of a site. Land use and access restrictions are potentially applicable institutional controls. Land use restrictions would limit the possible future uses of the land through the local forest management plan. Institutional controls involving access restrictions via mine portal closures, fencing and gates and/or land use controls do not achieve a cleanup goal. However, in addition to limiting access, these controls can provide for long-term public safety. **Institutional controls are retained** to complement cleanup and safety actions and will be combined with other process options.

TABLE 6-1
Response Technology Screening Summary
New World Mining District Response and Restoration Project
Miller Creek Response Action

General Response Action	Response Technology	Process Option	Description	Screening Comment
NO ACTION	None	Not Applicable	No Action	Retained for comparison with other options.
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing and Gates	Install fences around contaminated areas to limit access. Gating of access roads or mine portals	Potentially effective in conjunction with other technologies; readily implementable; not considered as a stand-alone alternative.
		Land Use Controls	Legal restrictions to control current and future land use	Potentially effective in conjunction with other technologies; readily implementable; not considered as a stand-alone alternative
		Portal Closures	Close mine portals with backfill, plugging or installation of locking barred gates. Also necessary for public safety.	Potentially effective closure option, readily implementable; may be considered as a stand-alone alternative or used in conjunction with other technologies; readily implementable.
ENGINEERING CONTROLS	Containment	Soil Cover	Native or imported soil used to cover waste; soil vegetated; covers contaminant source to prevent direct contact and reduces infiltration.	Reduces surface infiltration by evapotranspiration; Not effective in early spring or late fall when plants are dormant, or under conditions of peak infiltration; acid wastes may contaminate soil cover; readily implementable.
		Multi-layered Cap	Geomembrane layer covered with growth media and vegetation in contaminated surface areas.	Effective in isolating wastes from infiltration; site characteristics key to success; readily implementable; not cost effective for small sites.
		Asphalt or Concrete Cover	Apply asphalt or concrete over areas of exposed ore/mine waste.	Limited feasibility due to cracking over the long term under thermal extremes; long-term maintenance required.

Note: Shading indicates technology or process option retained for further consideration.

TABLE 6-1 (continued)
Response Technology Screening Summary
New World Mining District Response and Restoration Project
Como Basin/Glengarry Adit/Fisher Creek Response Action

General Response Action	Response Technology	Process Option	Description	Screening Comment
ENGINEERING CONTROLS (continued)	Surface Controls	Consolidation	Consolidate mine waste into single area.	Consolidation of mine dumps into larger area of disturbance; readily implementable; not retained because of the absence of a large single area for consolidation.
		Grading and Compaction	Grading and compaction of waste dump surfaces to reduce slopes for managing runoff, erosion and surface infiltration.	Grading alone does not reduce contaminant mobility; potentially effective if combined with other process options; compaction helps to reduce infiltration to some degree; readily implementable.
		Revegetation	Seed mine waste with adaptive plants; controls or reduces water infiltration by evapotranspiration and controls erosion.	Effective in stabilizing wastes which do not contain phytotoxic contaminant concentrations; acid soils affect plant establishment; readily implementable.
		Erosion Protection Runon / Runoff Control	Erosion resistant materials placed over mine wastes; storm-water diversion structures constructed to channel water away from mine wastes; lined and armored surface channels to maximize runoff from waste surfaces.	Potentially effective at reducing lateral contaminant migration; does not reduce contaminant mobility; potentially effective if combined with other process options; readily implementable.
	In Situ Capping	Soil Cover	Cover mine wastes with a soil cover.	Potentially effective. Increase water storage capacity and supports revegetation efforts. Readily implementable.
		Composite Cover	Cover mine waste with geomembrane and growth media cover system design.	Potentially effective and implementable, but not cost effective for the small, scattered sites in Miller Creek.
	On-Site Disposal	Existing Repository Facility	Excavate mine waste and dispose in on-site repository.	Potentially effective; on-site repository is in-place and has additional storage capacity; readily implementable.
	Off-site Disposal	RCRA Landfill	Excavate mine waste and dispose in RCRA-C permitted facility.	Potentially effective because contaminant sources would be removed; high costs associated with transportation, and disposal fees; implementable.
		Solid Waste Landfill	Excavate mine waste and dispose in non-hazardous solid waste facility.	Not feasible due to an administrative policy by the USDA that does not allow disposal of mining wastes at a solid waste facility. Potentially effective for non-hazardous materials or residue from other treatment options; readily implementable; cost very high due to long haul distances and disposal fees.

Note: Shading indicates technology or process option retained for further consideration.

TABLE 6-1 (continued)
Response Technology Screening Summary
New World Mining District Response and Restoration Project
Miller Creek Response Action

General Response Action	Response Technology	Process Option	Description	Screening Comment
EXCAVATION & TREATMENT	Reprocessing	Milling and Smelting	Excavate and either treat on-site to ship a concentrate or haul mine waste to operating mill and/or smelter for extraction of precious and non-precious metals.	Potentially effective if economic concentrations of metals are present; probably not cost effective to ship all wastes but if a concentrate is produced and shipped, this would partially remove contaminants. Reduces toxicity of the remaining wastes and improves quality and texture of mine waste remaining on-site for reclamation use. High capital costs.
	Fixation/ Stabilization	Cement/ Pozzolan Additive	Solidify mine waste with non-leachable cement or pozzolan.	Extensive treatability testing and proper disposal of stabilized material would be required. Potentially implementable but cost prohibitive.
		Lime Fixation	Mine waste treated with lime amendments to reduce mobility of metals.	Lime treatment of mine waste is a demonstrated technology in Montana. Effectiveness limited by depth of mixing. Arsenic mobility may increase.
	Physical/ Chemical Treatment	Soil Washing	Separate hazardous constituents from solid media via dissolution & precipitation.	Not effective for waste rock; potential exists to increase mobility by providing partial dissolution of contaminants; implementable; high cost.
		Acid Extraction	Mobilize hazardous constituents via acid leaching & recover by precipitation.	Effectiveness is questionable. Sulfides would only be acid soluble under extreme temperature & pressure; high cost.
		Alkaline Leaching	Use alkaline solution to leach contaminants from solid media in heap, vat, or agitated vessel.	Effectiveness not well documented for arsenic; not readily implementable; high cost.
		Fluidized Bed Reactor/Rotary Kiln/Multi-Health Kiln	Concentrate hazardous constituents into small volume by volatilization of metals & formation of metallic oxide particulates.	Further treatment required to treat process by-product. Potentially implementable; cost prohibitive.
		Vitrification	Extremely high temperature used to melt and/or volatilize all components of the solid media. Molten material containing contaminants is rapidly cooled to form vitrified, non-leachable product.	Not readily implementable for solid wastes; extensive treatability testing required; emission controls necessary; cost prohibitive.

Note: Shading indicates technology or process option retained for further consideration.

TABLE 6-1 (continued)
Response Technology Screening Summary
New World Mining District Response and Restoration Project
Miller Creek Response Action

General Response Action	Response Technology	Process Option	Description	Screening Comment
IN-SITU TREATMENT	Physical/ Chemical Treatment	Lime Fixation	Mine waste treated in-situ with lime amendments to reduce mobility of metals.	Lime treatment of mine waste is a demonstrated technology in Montana. Effectiveness is limited by depth of mixing. Arsenic mobility may increase.
		Solidification	Solidifying agents used in conjunction with deep soil mixing techniques to promote a physical or chemical change in mobility of contaminants.	Extensive treatability testing required. Potentially implementable; cost prohibitive.
		Soil Flushing	Acid/base reagents or chelating agents injected into solid media to solubilize metals. Pregnant solution with contaminants is extracted using dewatering techniques.	Effectiveness unknown; innovative process currently in pilot stage. Likely cost prohibitive.
		Reactive Barrier Wall	Construction of a downgradient hollow core permeable wall, hollow portion of the wall is filled with reactive treatment agents (iron-fillings, organic material, etc) through which contaminated water flows	Migration treatment technique, effective at removing metals and raising pH depending on filler material used, requires on-going maintenance, potentially expensive but effective and implementable
	Thermal Treatment	Vitrification	Contaminated solid media subjected to extremely high temperature in-situ. Rapid cooling vitrifies material into non-leachable product.	Potentially implementable but would require extensive pilot testing; site layout not ideal at certain sites due to steep slopes and lack of adequate access; cost prohibitive.

Note: Shading indicates technology or process option retained for further consideration.

6.1.3 Engineering Controls

Engineering controls are used to reduce the mobility of contaminants by establishing barriers that limit contaminant exposure, reduce contaminant reactivity, and prevent or limit migration or flow of contaminated surface or groundwater. Engineering controls typically include containment, capping, run-on/runoff controls, revegetation and/or disposal. Engineering controls generally do not reduce the volume or toxicity of hazardous materials. **Engineering controls are retained.**

6.1.3.1 CONTAINMENT

Containment technologies are used as source control measures. These technologies are designed to eliminate direct contact and fugitive releases of contaminated materials. In addition, such controls are used to divert and minimize infiltration of surface water/precipitation that may contribute to erosion and/or leachate formation. The cap or cover design is a function of the degree of hazard posed by the contaminated media and may vary from a simple soil cover to a multi-layered cap.

Capping is an appropriate alternative when contaminated materials are left on-site. A site-appropriate capping design is dependent on the relative toxicity and mobility of the contaminants and their demonstrated impacts to human health and/or environment. Capping also is an option when excavation and disposal or treatment actions are cost prohibitive. Capping of mine/mill wastes is a standard construction practice, uses standard equipment, and employs standard design methods. **Containment process options are retained** as a possible response action.

6.1.3.2 SURFACE CONTROLS

Surface controls are used to minimize contaminant release and migration. Surface controls alone may not be appropriate in areas where direct human contact is a primary concern. In these instances, surface controls are commonly integrated with containment to provide further protection. Surface control process options are directed at controlling water and wind erosion, and transport of contaminated materials. These options include consolidation, grading, revegetation, and erosion controls.

Consolidation involves grouping wastes of similar type in a common area for more efficient management or treatment. Consolidation is likely not important in the Miller Creek drainage area where multiple relatively small waste sources are present that are widely distributed throughout the valley.

Grading and compaction are used to reshape and compact waste areas in order to reduce slopes, manage the run-on/runoff and infiltration of surface water, and control erosion. Depending on site conditions, periodic maintenance may be necessary to control erosion problems after closure. Grading of the material in mine waste dumps may be an important surface control in the Miller Creek drainage.

Revegetation involves adding soil amendments to a limited depth in the waste in order to provide nutrients and organic materials to establish vegetation. Revegetation is essential to controlling water and wind erosion processes and minimizing infiltration of water through plant evapotranspiration processes. Revegetation generally involves the selection of appropriate plant species, preparation of the seeding area, seeding and/or planting, mulching and/or chemical stabilization, and fertilization. Depending on the success of revegetation, the site may require maintenance in order to establish a self-sustaining plant community.

Erosion protection includes using erosion resistant materials to control water and wind impact on the contaminated media surface. Processes include surface water diversions, application of mulch and natural or synthetic fabric mats, and rip rap. Erosion resistant materials are strategically placed based on knowledge of drainage area characteristics, slopes, vegetation types and densities, soil texture, and precipitation data.

Surface control process options grading, revegetation, and erosion protection are retained for inclusion into response alternatives. **Consolidation is not retained** because it would not be effective in controlling the release of hazardous substances alone.

6.1.3.3 ON-SITE DISPOSAL

On-site disposal can be used as a permanent source control measure. Contaminated media failing to meet toxicity characteristic leaching procedure (TCLP) criteria may require disposal in a RCRA hazardous waste-type repository and could be subject to RCRA landfill closure performance standards. Solid wastes from the beneficiation of ores and minerals, however, are not considered hazardous wastes under RCRA regulations (CFR 261.4 (b) (7)). This reclamation technology involves placing the untreated or treated contaminated materials in an engineered repository located on-site. An on-site repository was selected as the preferred alternative in the initial response action proposed for the District (Maxim, 2001b). This repository was constructed in 2001 and partially filled with mining wastes. Capacity exists to contain additional mine wastes and would be suitable for smaller mine waste dumps scattered about in the Miller Creek watershed. **On-site disposal technologies are retained** for further analysis.

6.1.3.4 OFF-SITE DISPOSAL

Off-site disposal involves excavating the contaminated materials and transporting them to an existing engineered repository permitted to accept such materials. Off-site disposal options include a RCRA-permitted repository or a solid waste landfill. Materials classified as hazardous waste as defined in RCRA would require disposal in a RCRA-permitted facility. Less toxic materials could possibly be disposed of in a permitted solid waste or sanitary landfill.

Off-site disposal was evaluated in detail in the initial response action considered for the District (Maxim 2001a), but was dropped because of high cost. There is also a general reluctance of these facilities to accept mining wastes and there remains a liability to the government if such a facility were used. For these reasons, the **off-site disposal alternative is not retained** for further analysis.

6.1.4 Excavation and Treatment

Excavation and treatment processes involve the removal of the contaminated materials and subsequent treatment to reduce toxicity and/or volume. Treatment processes may involve a variety of techniques including chemical, physical or thermal methods. These methods are used to concentrate metal contaminants for additional treatment or recovery of economic constituents (reprocessing) or to reduce the toxicity of hazardous constituents.

6.1.4.1 REPROCESSING

Reprocessing involves excavation and either on-site processing and shipping of a concentrate, or direct transportation of all contaminated materials to an existing mill or smelter for processing and recovery of valuable metals. Reprocessing of mine/mill wastes from outside sources is not commonly practiced due

to the low concentrations of metals in source materials, operating permits limiting processing of off-site materials, and liability issues. Applicability of this option is dependent on the concentration of economically viable elements and the ability and willingness of an off-site facility to process the material and dispose of waste.

Reprocessing of the wastes greatly reduces contaminant content and acidity of the wastes and improves the texture and chemistry of remaining mine waste so that it might be used for reclamation purposes. The cost of reprocessing large tonnage of moderately high-grade materials was found to be prohibitive for the analysis of the McLaren Pit waste rock materials (Maxim, 2001b). Based on the McLaren pit analysis, the cost of reprocessing the much smaller volumes of lower-grade materials also would be prohibitively expensive. In addition, the small size, wide geographic distribution, and low metal values of the mine waste dumps in Miller Creek do not warrant pursuing this process option. **On-site reprocessing is not retained** for further evaluation due to high capital costs.

6.1.4.2 FIXATION/STABILIZATION

Fixation/stabilization technologies employ treatment processes that chemically alter the contaminant to reduce its mobility or toxicity (fixation) or physically treat the contaminant by encapsulating it with an inert material (stabilization). The technology involves mixing materials with binding agents under specific conditions to form a stable matrix. For inorganic contaminants, fixation/stabilization employs a reagent or combination of reagents to promote a chemical and/or physical change in order to reduce the mobility. Fixation of acid-generating mine wastes with additives that raise the pH of the waste have been used widely in the last 25 years to reduce the mobility of metals. These additives include lime (calcium oxide), limestone (calcium carbonate), and calcium hydroxide. Other stabilization methods, such as phosphate addition (e.g., Envirobond) and the Dow manganese oxide passivation method have not been proven to be successful under field conditions and are not considered further. The in-situ process may use shallow surface, deep mixing, or complete incorporation techniques to achieve the best integration of the fixation agents with contaminated media.

In sulfide bearing rocks, sulfide minerals are oxidized and release metals and sulfuric acid. The solubility and rate of release of these metals is greatly increased by acidic conditions. The addition of lime as a neutralizing agent prevents the formation of acidic conditions and thereby restricts oxidation rate of the sulfide and the rate of metal release. Stabilization processes commonly use pozzolan/cement as additives. Obviously, the ability to ensure adequate mixing is a critical limitation for any amendment approach.

Fixation with lime is retained for further consideration. **Stabilization using pozzolans is not retained** due to higher costs associated with the process and large volume of materials.

6.1.4.3 PHYSICAL/CHEMICAL TREATMENT

Physical treatment processes use physical characteristics to concentrate constituents into a smaller volume for disposal or further treatment. Chemical treatment processes treat contaminants by adding a chemical reagent that removes or fixates the contaminant. Chemical treatment processes reduce toxicity and/or mobility of contaminants in solid media. Chemical treatment processes generally work in conjunction with physical processes to flush the contaminated media with water, acids, bases, or surfactants. Potentially applicable physical/chemical treatment processes include flotation (an ore beneficiation process use to concentrate sulfides), soil washing, acid extraction, vitrification, alkaline leaching, and concentration by volatilization.

Soil washing is an innovative treatment process that consists of washing the contaminated media with water in a heap, vat, or agitated vessel to dissolve water-soluble contaminants. Soil washing requires that contaminants be readily soluble in water and sized sufficiently small so that dissolution can be achieved in a practical retention time. Dissolved metal constituents contained in the wash solution are precipitated as insoluble compounds, and the treated solids are dewatered before additional treatment or disposal. Precipitates form a sludge that requires additional treatment such as dewatering or stabilization prior to disposal. At New World, this process would remove sulfate salts, but would not remove relatively insoluble oxide and sulfide minerals.

Acid extraction applies an acidic solution to the contaminated media in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of the metal constituents present in the contaminated media would be dissolved. A broader range of contaminants can be expected to be acid soluble at ambient conditions using acid extraction versus soil washing; however, sulfide compounds may only be acid soluble under extreme conditions of temperature and pressure. Dissolved contaminants are subsequently precipitated for additional treatment and/or disposal.

Alkaline leaching is similar to acid extraction in which a leaching solution, i.e., ammonia, lime, or caustic soda, is applied to the contaminated media in a heap, vat, or agitated vessel. Alkaline leaching is potentially effective for leaching the majority of metals from contaminated media; however, removal of arsenic is not well documented. Alkaline addition to promote formation of oxide armor on sulfide minerals would be expected to reduce arsenic release from arsenic-bearing sulfide minerals. Arsenic-bearing salts, or sorbed arsenic species, would tend to leach under alkaline conditions and could therefore be removed. **These process options are not retained** for further consideration due to associated high costs and large volumes of material to be treated.

Thermal treatment technologies apply heat to contaminated media in order to volatilize and oxidize metals. This process renders the contaminated media amenable to additional processing or it produces an inert product via vitrification. Potentially applicable thermal processes, which volatilize metals and form metallic oxide particulates, include the fluidized bed reactor, rotary kiln, and multi-hearth kiln. High temperature vitrification is another thermal treatment technology that essentially melts or volatilizes the contaminated media. Volatile contaminants and gaseous oxides of sulfur are driven off as gases and the non-volatile component is vitrified when it cools. **Thermal treatment is not retained** for further consideration due to its high cost and large volume of material to be treated.

6.1.5 In-Situ Treatment

In-situ treatment involves treating contaminated materials in place with the objective of reducing mobility and toxicity of problem constituents. In-situ treatments provide less control than excavation and treatment options because it affords less efficient mixing of additives. In-situ treatment technologies include physical/chemical and thermal treatment processes. Physical/chemical treatment technologies include lime fixation, solidification, soil flushing, and reactive barrier wall construction, while thermal treatment technology relies on the process of vitrification.

6.1.5.1 PHYSICAL/CHEMICAL TREATMENT

In-situ stabilization/solidification is similar to conventional stabilization in that a solidifying or chemical precipitating agent (or combination of agents) is used to create a chemical or physical change in the mobility and/or toxicity of the contaminants. Mine waste treatment with additives that raise the pH of the waste has been used widely and successfully in the last 25 years to reduce the mobility of metals.

These additives include lime (calcium oxide), limestone (calcium carbonate), kiln dust, and calcium hydroxide. The in-situ process uses both surface and deep mixing techniques to achieve the best integration of the solidifying agents with the contaminated media. ***In-situ fixation with lime is retained*** for further consideration.

Soil flushing is an innovative process that injects an acidic or basic reagent or chelating agent into contaminated media to solubilize metals. Dissolved metals are extracted using established dewatering techniques, and the extracted solution is treated to recover metals or is disposed as aqueous waste. Low permeability materials may hinder proper circulation, solution reaction, and ultimate recovery. Currently, soil flushing has only been demonstrated at a pilot scale. ***Soil flushing is not retained*** for further consideration because of the difficulty in implementing this technology at disperse sites that are situated in less than ideal environmental settings. The cost of this technology is expected to be high.

A ***Reactive Barrier Wall*** treatment technology is presented here as a migration and treatment control for infiltration or percolation waters that have been contaminated by passage through disturbed soils or waste materials. Some surface and/or groundwater components would also be treated by this treatment technology because it could not be separated from contaminated waters at the point of treatment. A permeable barrier wall is constructed downgradient of the contamination source, to force surface and/or groundwater to flow through the wall. The wall is constructed as a thick and hollow wall that is filled with reactive material (iron filings, organic material, limestone or various other reactive agents) that reacts with contaminated water as it flows through the wall. The wall is isolated from atmospheric conditions and thermal stresses with a cover of low permeability material. Contaminants including sulfate, nitrate, and a variety of metals have been successfully removed in this way. Reactive barrier walls have been shown to be effective in the treatment of migrating contaminated groundwater on both pilot and full-scale field-testing projects, and a dozen or more are currently in use on various projects at the present time. There is established EPA guidance for their application. They are cost effective to construct and an excellent method to treat contaminated surface or groundwater along its migration pathway. Long-term maintenance is required as the agent filling the wall must be replaced periodically over time as it loses its reactive properties or becomes plugged with precipitated contaminants.

The University of Waterloo holds the patent for the reactive barrier technology for treating acidic mine waters. Reactive barriers consist of four main components: an organic carbon source, a bacterial source, a neutralizing source, and a non-reactive porous medium. The organic source is usually made up of composted leaf mulch, composted municipal sewage waste, sawdust, composted manure and delignified cellulose, either placed alone or in some sort of a mixture. The bacterial source consists of sulfate reducing bacteria that are either cultured and grown in a laboratory or obtained from natural occurring sources. The neutralizing source is usually limestone and usually added at approximately 1-2% by volume or 2-7% by weight. Sand or gravel is mixed with the mixture to increase permeability of the mixture and is usually 5-10% by volume. The permeability of the mixture is an important parameter that must be considered while designing a reactive wall. The mixtures should be designed such that the permeability is the same as, or slightly greater than, that of the surrounding soil or aquifer material. The permeability usually ranges from 10^{-3} cm/sec to 10^{-4} cm/sec. Because of this low permeability, the systems are best designed for treating small volumes of groundwater. In order for the sulfate reducing bacteria to be effective, a clay cap (typically 25 to 40 cm of clay) needs to be placed on the barrier to prevent diffusion of oxygen and allow reducing conditions to develop. Bacteria are tolerant to a temperature range of 23 to 150 °F. The optimum temperature range for sulfate reducing bacteria is 60 to 80 °F. Low temperatures, such as are present for rather long periods of time at the New World project site would reduce the efficiency and applicability of the bacteria media in the reactive barriers drastically.

A detailed pilot-scale study would be required in order to evaluate the effectiveness and applicability of this technology at the New World site. A better understanding of the groundwater flow and velocity is also needed to accurately design this remedial system.

Reactive barrier walls are not retained as a migration pathway treatment process, as active source control options should be applied and monitored for success prior to implementing migration control treatment. Reactive barrier walls may best be considered as a second level treatment option if primary source controls do not provide the level of contaminant control desired.

6.1.5.2 THERMAL TREATMENT

In-situ vitrification is an innovative process used to melt contaminated solid media in place to immobilize metals into a glass-like, inert, non-leachable solid matrix. Vitrification requires significant energy to generate sufficient current to force the solid media to act as a continuous electrical conductor. This technology is seriously inhibited by high-moisture content. Gases generated by the process must be collected and treated in an off-gas treatment system. In-situ vitrification has only been demonstrated at the pilot scale, and treatment costs are extremely high compared to other treatment technologies.

Thermal Treatment is not retained for further consideration because of the difficulty in implementing this technology at disperse sites that are situated in less than ideal environmental settings. The cost of this technology is expected to be high.

6.2 RESPONSE ALTERNATIVE DEVELOPMENT

The most promising technologies and process options that were identified and retained through the screening process are summarized in **Table 6-2**. These options appear to be effective and readily implementable for a reasonable cost and will be used to develop response action alternatives for further consideration.

EPA guidance for non-time-critical removal actions suggests that only the most qualified technologies that apply to the media or source of contamination be evaluated in detail in the EE/CA. Using this guidance, response action alternatives for the Miller Creek Response Action were developed by combining reclamation technologies and process options such that each alternative fulfilled in whole or part the RAOs and goals for the project. The No Action alternative is the one exception to this statement but the No Action alternative is used in the detailed analysis as a baseline against which the other alternatives can be compared. Assembling the alternatives was accomplished by combining process options so that each alternative either offered a distinct benefit over another alternative, or provided a different approach to meeting the RAOs and goals. The alternatives also cover a reasonable range of costs, an important factor that will be considered in the detailed analysis.

Response action alternatives developed for the Miller Creek area are presented in **Table 6-3**. There are 46 small, scattered, mine waste dumps throughout the Miller Creek valley. Twenty-six of these dumps occur on District Property. The dumps are scattered over a wide area, and access is difficult to many of the sites. For these reasons covering the small waste dumps with a geocomposite liner system, as was designed and selected as a response action for the larger mine waste covered areas in the McLaren Pit and Como Basin areas, is not considered practical or cost effective for the Miller Creek dumps.

TABLE 6-2 Process Options Retained From Technology Screening New World Mining District Response and Restoration Project Miller Creek Response Action		
General Response Action	Response Technology	Process Option
No Action	None	Not Applicable
Institutional Controls	Access Restrictions	Fencing/Signage
		Land Use Controls
		Portal Closures and/or Gates
Engineering Source Controls	Surface Controls	Grading/Compaction
		Revegetation
		Erosion Protection, Runon/Runoff Control
	In-Situ Capping and Containment	Soil Cover
	On-Site Disposal	Disposal in the Existing Selective Source On-Site Repository with Leachate Collection System
Excavation and Treatment	Fixation/Stabilization	Lime Fixation
In-Situ Treatment	Physical/Chemical Treatment	Lime Fixation

TABLE 6-3 RESPONSE ACTION ALTERNATIVES FOR THE MILLER CREEK SOURCE AREA New World Mining District Response and Restoration Project Miller Creek Response Action		
Alternative		Response Technology/Process Options
MC-1	No Action	None
MC-2	In-Situ Reclamation of Mine waste Dumps	Grading and compaction of mine waste in-situ, constructing runon and runoff controls, amendment of the upper 30 cm of the regraded surface with lime, revegetation, and erosion protection.
MC-3	Total Removal and Disposal in an On-Site Repository	Total removal and disposal of waste in the Selective Source repository.

Three response action alternatives are considered for mine waste dumps in the Miller Creek valley: MC-1, No Action; MC-2, In-Situ Reclamation; and, MC-3 Total Removal and Disposal in an On-Site Repository (SB-4B(I)). Alternative MC-2, In-Situ Reclamation, is considered appropriate for some of the remaining mine waste dumps. However, due to site and size constraints and access limitations (i.e. many of the dumps are very small and are on steep slopes that constrains lime mixing with equipment) this alternative is not appropriate for all sites. This alternative may include some or more likely all of the following activities: grading and compaction of the waste in-situ, construction of runon and runoff controls, amendment of the upper 30 cm of the regraded waste surface with lime and nutrients, revegetation, and erosion protection. Total removal to the Selective Source repository area is considered also appropriate for the Miller Creek Source Area.

7.0 DETAILED ANALYSIS OF RESPONSE ALTERNATIVES

Response alternatives developed in the previous section are analyzed and compared in detail in this section. Response alternatives represent a range of potential actions that can meet, to some degree, RAOs for this portion of the project, and achieve distinct levels of protectiveness to human health and the environment for a reasonable range of costs.

7.1 EVALUATION CRITERIA

The following three criteria will be used to evaluate response action alternatives:

1. Effectiveness
2. Implementability
3. Cost

According to EPA guidance for non-time-critical removal actions (EPA, 1993), the effectiveness of an alternative should be evaluated by the following criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and, short-term effectiveness. The ability of each alternative to meet RAOs is considered when evaluating these criteria.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required to accomplish its implementation. Technical feasibility considerations include the applicability of the alternative to the waste source, availability of the required equipment and expertise to implement the alternative, and overall reliability of the alternative. Administrative feasibility evaluates logistical and scheduling constraints.

Evaluating the cost of alternatives involves developing conservative cost estimates based on the materials needed and the construction elements associated with implementing the alternative. These costs do not necessarily represent the cost that may actually be incurred during construction of the alternative because many design details are preliminary at this stage. However, a similar set of assumptions is used for all the alternatives so that the relative differences in cost between alternatives are fairly represented. Unit costs were developed by analyzing data available from USDA-FS and nationally published cost estimating guides. Where possible, cost data incorporate actual operating costs and unit costs that have been realized during similar reclamation projects. Unit costs are based on assessments of materials handling and procurement, site conditions, administrative and engineering costs, and a contingency.

In addition to the capital costs discussed above, post-removal site control (PRSC) costs are estimated for the alternatives. These PRSC costs were estimated using reasonable assumptions for likely and potential maintenance and monitoring requirements. PRSC costs for the No Action Alternative were calculated using the same monitoring costs as the active alternatives, but without the costs for monitoring and maintenance of revegetation. Average annual PRSC costs are estimated for a 30-year period. The present worth for PRSC is calculated using a discount rate factor of 4.9% (OSWER, 1993).

The total estimated project cost for each alternative is the sum of the estimated capital cost, the estimated present worth PRSC cost, and engineering design and construction oversight costs which are calculated as a percentage of the estimated capital cost. In line with EPA guidance, the total estimated cost is expected to be within plus 50% and minus 30% of actual costs.

Costs presented in this section are based on waste volumes determined from Maxim's 1999 field investigation, and supplemented, corroborated, or modified by more recent site specific mine waste site inventories. Areas were calculated from measurements made on aerial photographs. Summary cost tables are presented in the cost discussion for each alternative with the supporting unit cost spreadsheets presented in Appendix D.

7.2 ANCILLARY ITEMS

Road rehabilitation and other restoration work, and work considered for the Cumberland dump are considered as an ancillary action in this EE/CA and, therefore, is included in each alternative as a line item cost (except for the No Action Alternative). A detailed description of proposed restoration work is provided in Section 3.7. This section summarizes the costs associated with restoration work.

7.2.1 Glengarry Wetland

The Glengarry wetland would involve several steps, beginning with diversion of water to dry the area followed by recontouring and channel excavation. Channels would be lined with appropriate materials, topsoil spread, and vegetation planted in the channels and on the adjacent low-lying banks. The estimated cost of wetland restoration is shown in **Table 7-1**.

TABLE 7-1 GLENGARRY MINE WETLAND COSTS New World Response And Restoration Project Miller Creek Response Action EE/CA				
Item	Quantity	Units	Unit Price	Total
Stream diversion	1	LS	\$5,000	\$5,000
Regrading	5,000	m ²	\$1.00	\$5,000
Type A Channel construction	200	m	\$50	\$10,000
Type B Channel construction	200	m	\$150	\$30,000
Furnish and place topsoil	5,000	m ²	\$1.50	\$7,500
Furnish and plant plugs	26,600	ea	\$1.50	\$39,900
Total				\$97,400

7.2.2 Road Rehabilitation

Summary costs associated with road rehabilitation are shown in **Table 7-2**. Detailed costs are presented in Appendix C. A lump sum of \$10,000 was added to the road rehabilitation cost to allow for road improvements on the Fisher Creek road from U.S. Highway 121 to the Glengarry Mine (this section of road has already seen a lot of rehabilitation work).

7.2.3 Cumberland Dump

Cleanup of the Cumberland Dump would involve separating the combustible and non-combustible debris, segregating mine assay equipment, and then loading and hauling non-combustible debris to a solid waste disposal facility. Estimated costs for this item are shown in **Table 7-3**.

TABLE 7-2 ROAD TREATMENT COSTS New World District Response and Restoration Project Miller Creek Response Action EE/CA					
Objective	USDA-FS Road Type	Drainage	Kilometers	COST (\$)	TOTAL COST (\$)
Road Closures	Obliteration Type I	None	0	0	0
	Reclamation Type I Roads	Daisy	0.938	18,524	
		Fisher	3.317	65,504	
		Miller	6.328	124,946	
		Soda Butte	0.916	18,089	
		W. Rosebud	0.036	711	
		Total	11.535	227,793	227,793
Road Upgrade	Drain and Leave Open Type 2 Roads	Daisy	2.702	30,367	
		Fisher	5.559	51,616	
		Miller	1.634	9,293	
		Soda Butte	3.025	26,487	
		Stillwater	0.087	407	
		W. Rosebud	0.0	205	
		Total	13.007	117,764	117,764
Restricted Use	Restricted Width Type 3 Roads	Daisy	1.070	11,275	
		Fisher	3.324	18,330	
		Miller	5.225	29,453	
		Soda Butte	4.100	24,531	
		W. Rosebud	0.079	157	
		Total	13.798	83,747	83,747
	Administrative Closure- Type 4	Daisy	0.305	2,000	
		Total	0.305	2,000	2,000
Road Upgrade	Improve Drainage and Revegetate Type 5 Roads	Daisy	2.100	25,013	
		Fisher	0.080	28,842	
		Miller	4.139	59,658	
		Soda Butte	0.389	5,375	
		W. Rosebud	0	0	
		Total	6.708	117,764	117,764
Special	Fisher Creek Road	Fisher	--	10,000	10,000
Grand Total			45.353		558,193

TABLE 7-3
CUMBERLAND DUMP CLEANUP COSTS
New World Response and Restoration Project
Miller Creek Response Action EE/CA

Item	Quantity	Units	Unit Price	Total
Collect and segregate debris	4	man days	\$250	\$1,000
Load debris - labor	0.5	man days	\$125	\$125
Loader and truck	1	LS	\$1200	\$1200
Haul debris to a landfill and tipping	1	LS	\$2400	\$2400
Hand regrading of disturbed areas	2	man days	\$250	\$500
Drainage Control	1	LS	\$1500	\$1500
Selective revegetation	0.1	ha	\$47,619	\$4,750
Per Diem	7	man days	\$70	\$490
Total				\$11,965

7.2.4 Bull-of-the-Woods Pass Shaft

An open inclined shaft at the Bull-of-the-Woods Pass is associated with the Black Warrior Mine and presents a hazard to hikers, snowmobilers, and other recreationists due to its near-vertical construction and depth to bottom. This shaft will be closed as an ancillary item under the Miller Creek Response Action.

7.3 MILLER CREEK SOURCE AREA ALTERNATIVES

This section presents the detailed analysis of alternatives for potential response actions for the Miller Creek Source Area. The Miller Creek Source Area contains 46 relatively small, scattered, outlying mine waste dumps (26 of which are on District Property) located throughout the Miller Creek watershed. These smaller mine waste dumps, identified in **Table 3-1** and shown on **Figure 3**, contain acid-generating sulfides and heavy metal contaminants with potential contaminant migration issues.

7.3.1 No Action - Alternative FC-1

The No Action Alternative involves leaving the Miller Creek mine waste sites in their existing unvegetated condition, subject to continuing erosion and locally impacting surface water quality. No reclamation would be done at the sites to control contaminant migration or reduce toxicity or volume. Periodic maintenance may be required if erosion of mine waste dumps increases to unacceptable levels or threatens other resources.

7.3.1.1 EFFECTIVENESS

The No Action Alternative does not address surface water quality impacts, nor does it provide any controls on contaminant migration via direct contact or particulate emissions. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative. Protection of the environment would not be achieved under this alternative. Only one of the RAOs would be met for the site -- preserving the existing undeveloped character of the District and surrounding area.

7.3.1.2 IMPLEMENTABILITY

This alternative is both technically and administratively feasible. However, it is not a reliable means of controlling mining wastes that impact environmental receptors.

7.3.1.3 COST

No capital costs would be incurred under this alternative. However, long term costs associated with no action are unknown since there is an on-going risk that unstable mine dumps may fail, resulting in damage to other resources and requiring action. In addition, there are external costs associated with no action, including the loss of certain ecological functions such as a healthy, viable aquatic community. Using the PRSC costs presented in Appendix C, the total monitoring costs for monitoring over a 30-year period is about \$37,300.

7.3.2 In-Situ Reclamation - Alternative MC-2

Alternative MC-2 involves surface controls, grading and run-on and runoff controls, treating the wastes in-place with a neutralizing amendment, and revegetation. **Figure 19** shows a schematic of the alternative components. A description of the alternative is presented below, followed by the detailed analysis.

7.3.2.1 ALTERNATIVE TASK DESCRIPTION

- *Road Improvement:* The existing condition of the majority of roads that access the dump sites is only fair to poor. Road improvements required to get equipment to the mine waste dump sites will involve widening and grade reduction, cut and fill, and installing temporary culverts. Some sites may require new road construction, which will involve constructing a disturbed road width of six meters (20 feet), dozer grading to establish a 3.7-meter-wide (12 feet) travel width, and installing turnouts. A total of about 5.05 km (3.4 miles) of road improvement and new construction will be required to access the mine waste dumps under this alternative. Total disturbance associated with road improvements is expected to be 3 hectares (7.4 acres). All new access roads and some existing access roads will be fully reclaimed after the site activities are complete. Other roads will be returned as closely as possible to their previous condition.
- *Site Preparation:* This item includes clearing and grubbing, separating combustible and non-combustible debris, and debris disposal from waste surfaces and adjacent areas.
- *Regrade Waste Dumps:* Mine waste dumps would be regraded to a stable configuration as allowed by site constraints in order to minimize surface erosion. Wastes in contact with surface water would be pulled back so that the wastes are out of the surface water-course. Regrading would be done to blend in with the surrounding topography.
- *Surface controls:* Surface controls would be implemented at those dumps where run-on and runoff move through mine waste or other disturbed areas. Surface controls include diversion of surface water, minor grading, and erosion control measures such as straw bales or silt fence
- *Treat Waste with Neutralizing Amendment:* A neutralizing amendment, such as agricultural limestone, lime kiln dust, or calcium oxide would be mixed into the top 30 cm (1 foot) of the waste at an average rate of 114 metric tons per thousand metric tons (actual values would be calculated on a dump-by-dump basis during reclamation). The estimated total lime required to amend mine waste on District Property in Miller Creek is 273 metric tons.

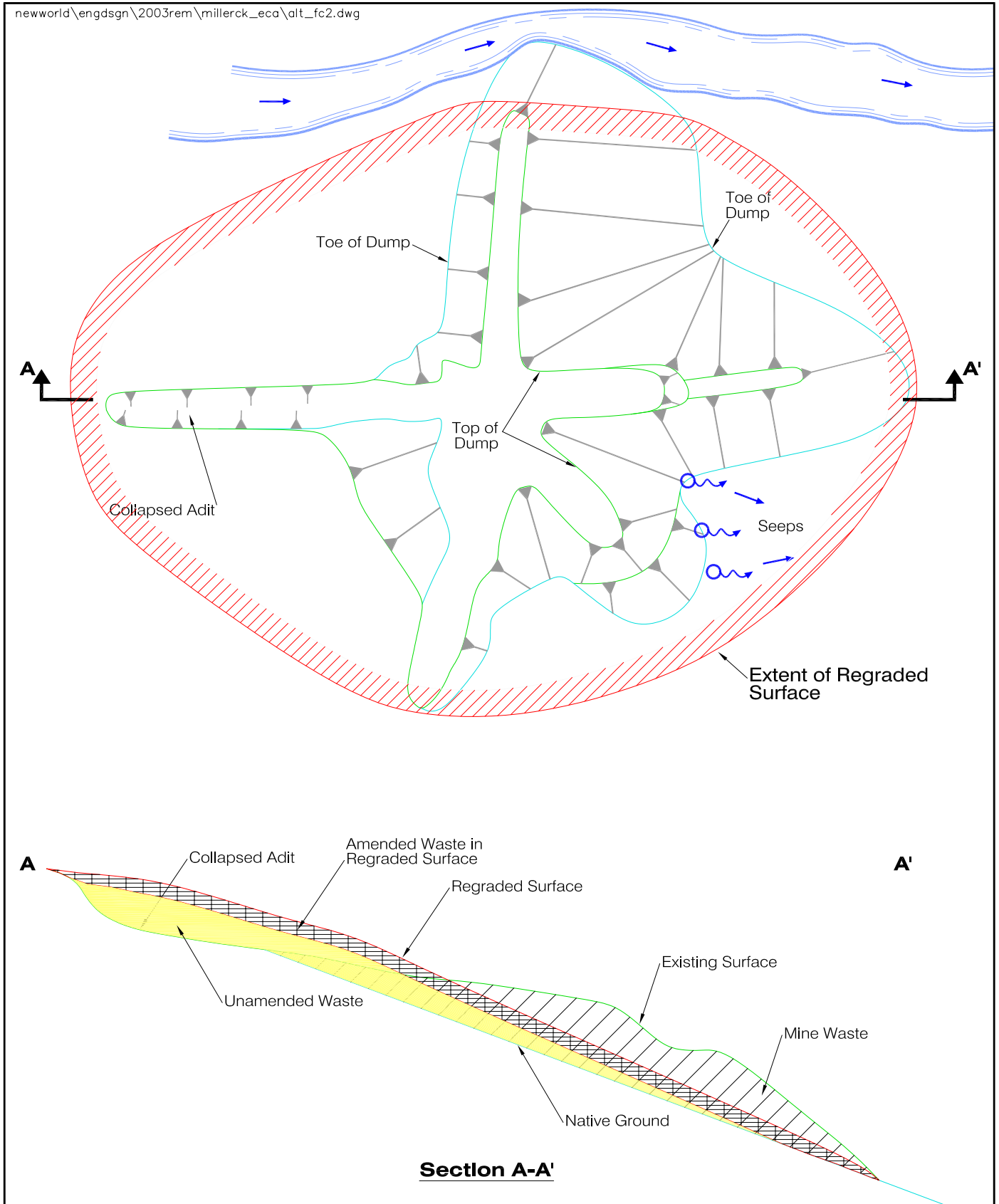
- *Revegetate Waste Dump Sites:* After neutralization, prescriptions for revegetation will follow those developed by the USDA-FS Rocky Mountain Research Station specifically for revegetating amended mine wastes in the District. These prescriptions are summarized in the *1999 Revegetation Monitoring Report* (Maxim, 1999f). Revegetation prescriptions for mine waste specify amount and types of amendments recommended for organic matter, fertilizer, seeding, mulching, and use of erosion control.
- *PRSC:* Surface water and groundwater monitoring; monitoring and maintenance of vegetation; monitoring and maintenance of physical stability.

7.3.2.2 EFFECTIVENESS

Overall, *in-situ* reclamation involves surface controls, regrading, shallow amendment and revegetation. Surface controls involve regrading and rerouting of surface water flows that will reduce contaminant movement in surface water by reducing the amount of water that moves over and through the waste dumps. Shallow amendment and treatment would be effective in providing suitable soil conditions for revegetation in the short-term, and a corresponding reduction in mobility of metal contaminants. However, because site conditions limit the depth of waste treatment, untreated wastes will remain at the sites. Under certain conditions, generally during moderate to extreme weather, untreated wastes could become saturated and release contaminants to the environment. There is also the potential for the treated surface of the waste to reacidify due to capillary rise of acid from underlying untreated wastes, resulting in a reduction in vegetation cover and vigor. Such a mechanism could cause the waste dump to revert to near pre-treatment conditions.

❖ REMOVAL ACTION OBJECTIVES

In-situ reclamation meets most of the RAOs to some extent. Surface controls, regrading to re-route surface water, and revegetating the sites will meet the RAO of reducing or eliminating concentrated runoff and sediment discharges. By neutralizing the upper 30 cm of waste to a pH of greater than 6.0 s.u., phytotoxicity of the waste will be reduced to the extent that plants will grow directly in the amended waste. Revegetating the waste dumps will reduce the amount of water infiltration that dissolves metals and then migrates from the dumps to surface water. Soluble metals will not be eliminated because some portion of the wastes in the dump will remain untreated and in contact with infiltrating precipitation. Animal exposure to metal contaminants via ingestion of soil and dust inhalation will be reduced to a large extent in the treated waste dumps, except possibly for a small residual risk for animals that graze on vegetation growing in treated areas (potential for elevated metals in vegetative tissue) and burrowing animals that penetrate the amended waste layer (exposure to untreated wastes via ingestion and direct contact).



Not to Scale

❖ OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Three mine waste sites in Miller Creek have human health risks associated with the concentration of metals in the waste. At two of these sites, the Black Warrior (MCSI-96-2) and Upper Miller Creek Dump (MCSI-96-3; volume 60 cubic meters; located on private land), lead and zinc concentrations pose a human health risk. At the third site, the Alice E Pit and Dump Complex, only lead concentrations pose a human health risk. This site also occurs on private land. There are no identified unacceptable human health risks associated with the average concentration of metals present in waste at the remaining dump sites in Miller Creek. *In-situ* reclamation does provide a reasonable measure of control of exposure to contaminated materials and reduces risk to the environment. Surface controls reduce the potential for further erosion and migration of contaminants from source areas by surface water, by stabilizing the wastes through regrading. Some risk remains at two dumps located proximal to Miller Creek, the Miller Creek Dump #1 (MCSI-99-72) and Miller Creek Dump #2 (MCSI-96-1), because these dumps are more prone to exposure and erosion by flooding. This is not the case for the majority of dumps in Miller Creek, however, because most dumps lie on the slopes of Henderson Mountain, Crown Butte, and Miller Mountain. Other physical processes may affect the integrity of this alternative on the hillside dumps, including avalanches and severe rainstorms. While maintenance of dumps will reduce the risk of failure to some extent, maintenance will not prevent failure under extreme conditions that occur in a relatively short period of time (hours or days). Shallow lime and nutrient amendment, combined with regrading of wastes reduces the potential for further erosion and migration of contaminants from source areas near surface water drainages by stabilizing the wastes and also provides a graded and amended surface for revegetation. The establishment of vegetation at the dump sites greatly reduces the principal pathway of risk to humans, which is by inhalation or ingestion of soils.

❖ COMPLIANCE WITH ARARS

Compliance with ARARs may not be fully achieved under Alternative MC-2, even when combined with sediment control from roadways, without other cleanup actions that address cleanup of natural sediment sources that include the barren slopes with anomalously high metals concentrations on the southwest flank of Henderson Mountain. Under current conditions, the exceedance of water quality standards principally occurs during high flow events (with the exception of copper), which strongly suggests that contaminants are associated with sediment transported in surface waters.

Groundwater quality in the Miller Creek drainage has been measured in only three wells and varies considerably. The two wells located in the upper Miller Creek drainage (MW-5P, a bedrock well; and 5A, an alluvial well) are in compliance with groundwater quality standards in both shallow alluvial aquifer and the bedrock well completed in the Wolsey Shale in the Crown Butte Fault Zone. The other well (MW-6) is located immediately down gradient of the Alice E Pit and dump complex and exceeds the standards for arsenic, cadmium, lead, and manganese (one sample event only). *In-situ* treatment of mine waste dumps and sediment control from roadways will likely have no effect on groundwater. The Alice E Pit and waste rock dumps are located on private land, and, because of this, are not considered for reclamation activities in this EECA. Therefore, no significant change in degraded groundwater quality immediately below the Alice E Mine site is expected.

Contaminant-specific ARARs for ambient air are expected to be met under this alternative because the wastes will be revegetated.

Location-specific ARARs, particularly those associated with cultural and historic resources, are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash; backfilling collapsed

adits; and, regrading mine dumps. Historic structures and debris located adjacent to the dumps (like that at the Little Daisy Mine and Millsite and at the Black Warrior Mine) will be protected. Historic structures and debris that can be easily salvaged will be moved off the dumps and protected to represent elements of the former mining features. Requirements of the National Historic Preservation Act and the Archaeological and Historic Preservation Act will be met through consultation with the State Historic Preservation Office by the USDA-FS, and mitigation of cultural and historic impacts on the District as a whole.

Threatened and endangered species are present in or near the District. The U.S. Fish and Wildlife Service has identified the grizzly bear, bald eagle, Canada lynx, and gray wolf as threatened and endangered species that may be present in the project area. No critical habitat was designated or proposed in the project area, although the District lies within the Grizzly Bear Recovery Zone for the Yellowstone area. Long-term impacts to threatened and endangered species from the proposed action are not expected, although risk to grizzly bear mortality may be higher due to the increased use of the area. Also, displacement of wildlife species such as the grizzly bear may be increased by reclamation activities in the short-term.

Although construction and implementation of the alternative will require an increased level of activity, long-term maintenance will not require a level of activity that is greater than that existing under current conditions. In the long term, mitigation of mining-related water quality impacts in the District should serve to enhance wildlife habitat by removing contaminants from the environment. The overall impact of response and restoration activities is neutral to beneficial to wildlife, although road improvements that are being done over the life of the project could have long-term impacts on wildlife due to increased traffic, increased traffic speeds, and increased use of the area.

Other location-specific ARARs will be protected through substantive compliance with the requirements of laws related to streambeds and wetlands. The Floodplain and Floodway Management Act does not directly apply because the streams adjacent to the selected waste dumps are not in a designated 100-year floodplain. The Natural Streambed and Land Preservation Act (§§ 75-7-101 *et seq.*, MCA) will be complied with at those sites where wastes are in contact with surface water because waste will be moved away from the stream, and the affected streambanks will be reconstructed with earth and natural materials and sufficiently protected with erosion control techniques so that the bed and banks are protected from flood erosion. Reconstructed streambed and banks will be designed to provide hydraulic stability. All disturbed areas will be managed during construction to minimize erosion. Protecting wetlands will be accomplished by avoiding, to the extent possible, adverse impacts to wetlands.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using Best Management Practices (BMPs) at the treated dump sites. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment. The Montana Water Quality Act will not be fully complied with under this alternative. Unamended wastes (below the upper 30 cm that are amended) will likely be in contact with groundwater from adit seeps and may also become saturated during periods of high groundwater levels.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 *et seq.*).

Regrading and amending treated sites would substantively meet revegetation requirements contained in the Surface Mining Control and Reclamation Act, Montana Strip and Underground Mine Reclamation

Act and Metal Mining Act. Native species have been selected through many years of USDA-FS research in the District on amended wastes. BMPs for seeding, planting, mulching, soil amendments, control of noxious weeds, and erosion control will also be followed under this alternative.

Hydrological regulations contained in the Montana Strip and Underground Mine Reclamation Act would be met by minimizing any changes to the hydrologic balance. Other requirements for treating surface drainage, sediment control, construction and maintenance of sedimentation ponds, discharges from sedimentation ponds, and provisions for groundwater will be met by using best available technologies (BAT).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using BMPs.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

❖ LONG-TERM EFFECTIVENESS AND PERMANENCE

Most of the waste dumps considered under this response action are very small. Because the entire package of waste materials at each dump site cannot be fully amended under this alternative, *in-situ* reclamation may not be a permanent solution. Acidity from unamended wastes lying below the amended zone has the potential to move upward into the treated zone through capillary action. If this condition occurs, retreatment of the wastes may be necessary if vegetation is impacted through a reduction in cover or vigor. Amended wastes are also subject to erosion and unamended wastes may eventually resurface. PRSC monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term.

❖ REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

There will be some reduction in mobility but no reduction of toxicity or volume under this alternative. Reduction in the mobility of contaminants will be achieved through treatment with a neutralizing amendment.

❖ SHORT-TERM EFFECTIVENESS

This alternative should allow completion of *in-situ* treatment in a single construction season of not more than 60 days. Therefore, impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures.

The major short-term impact to the surrounding community, residents, and wildlife involves increased vehicle traffic and temporary closures of some forest roads. An increase in traffic will occur during mobilization and demobilization of construction equipment.

Short-term road closures in the project area may be necessary, limiting access to the forest. Increased traffic may impact wildlife by either changing daily migration patterns or exposing wildlife to a higher potential for injury or death due to collisions with vehicles.

Short-term air quality impacts to the immediate environment may occur during regrading and mixing of neutralizing amendment. Control of fugitive dusts may thus require the use of BMPs. Dust control on designated truck routes is an expected requirement.

Road improvements needed to implement this alternative may have some short-term impacts on the watershed. Increased sedimentation may result from road improvements due to an increased sediment load from exposures in widened roads and deeper and wider borrow ditches. Implementing BMPs for storm water runoff will mitigate these impacts.

7.3.2.3 IMPLEMENTABILITY

In-situ reclamation is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available and would allow the timely implementation and successful execution of the alternative.

7.3.2.4 COST

Estimated costs for Alternative MC-2 are shown in **Table 7-4**. Construction of the items involved with implementing the alternative will be about \$223,000. Ancillary items are estimated to cost about \$668,000. Total cost for this alternative is about \$1,061,000. The detailed cost analysis is presented in Appendix D.

7.3.3 On-Site Disposal - Alternative MC-3

Alternative MC-3 involves removal of mine waste from dumps located on District Property (**Table 3-1**) to the Selective Source repository site, which is an on-site repository that was constructed specifically to dispose of mine wastes present in the District. Under Alternative MC-3, all dumps identified for removal will be fully removed. The haul route to the repository would be the Daisy Pass Road to the newly constructed upper connect road that connects the Daisy Pass and Lulu Pass roads.

7.3.3.1 ALTERNATIVE TASK DESCRIPTION

The following work activities are included in the construction of Alternative MC-3:

- *Road Improvement:* The existing condition of the majority of roads that access the dump sites is only fair to poor. Road improvements required to get equipment to the mine waste sites will involve widening and grade reduction, cut and fill, and installing temporary culverts. Some sites may require new road construction, which will involve constructing a disturbed road width of six meters (20 feet), dozer grading to establish a 3.7-meter-wide (12 feet) travel width, and installing turnouts.

TABLE 7-4 SUMMARY OF TOTAL ESTIMATED COSTS FOR MILLER CREEK ALTERNATIVE MC-2 New World Mining District Response and Restoration Project Miller Creek Response Action EE/CA	
Item	Estimated Cost
Upgrade Access Roads	\$47,384
Clear and Grub	\$1,564
Waste Spreading and Grading	\$12,033
Incorporate Lime in Upper 0.3 meters	\$16,963
Drainage Channels	\$27,000
Erosion Control	\$3,830
Reclaim Access Roads	\$34,592
Revegetation	\$35,031
Subtotal	\$178,399
Mobilization (10%):	\$17,839
Contingency (12%):	\$21,407
TOTAL CONSTRUCTION ESTIMATE:	\$222,798
Ancillary Actions	
Road Rehabilitation	\$558,193
Glengarry Wetlands	\$97,400
Cumberland Dump Debris Cleanup	\$11,965
Subtotal	\$667,558
Engineering Evaluation and Design (8%):	\$71,228
Construction Oversight (5%):	\$44,517
Present Worth Post-Removal Site Control Estimate:	\$54,759
TOTAL ESTIMATED COST	\$1,060,862

A total of about 5.05 km (3.4 miles) of road improvement and new construction will be required to access the mine waste dumps under this alternative. Total disturbance associated with road improvements is expected to be 3 hectares (7.4 acres). All new access roads and some existing access roads will be fully reclaimed after the site activities are complete. Other roads will be returned as closely as possible to their previous condition.

- *Site Preparation:* Clearing and grubbing; separating combustible and non-combustible debris; and, debris disposal.
- *Excavate/Load Waste:* Excavate and load all waste from District Property waste dumps located in Miller Creek. Assuming a swell factor of about 15%, a total of 3,622 cubic meters (4,737 cy) of mine waste would be excavated and loaded onto haul trucks.
- *Construct Repository:* The Selective Source repository would be expanded to accept the additional volume of mine waste from the Miller Creek dump sites (about 3,622 cubic meters). This action would likely be coordinated with other removals planned for the District, such as the removal of the

Glengarry and Gold Dust dumps, which is currently scheduled for 2005. Expanding the repository would involve the following:

- Salvaging soil from the disturbed area.
 - Excavating the area to a design depth of 1 m (3 feet) and stockpiling excavated materials.
 - Preparing the subgrade of the repository by compacting to a specified density.
 - Constructing run-on and runoff control ditches around the perimeter of the repository.
 - Constructing a perimeter drainage trench to intercept subsurface flow.
 - Blasting rock from a nearby source to provide material for a rock toe.
 - Crushing rock from a nearby source to provide sand and gravel or importing this material from an off-site source.
 - Constructing a multilayered cover on top of the waste that includes a geosynthetic liner, a geocomposite liner, a drainage system, and soil layer.
 - Revegetating the repository cap with an appropriate seed mix and mulch.
 - Covering the cap with an erosion control blanket.
- *Haul Waste to Repository:* Truck wastes to the on-site repository and place and compact waste.
 - *Regrade and Revegetate Mine Waste Dump Sites:* Regrade excavated areas; amend excavated surface with lime and fertilizer, seed, mulch, and cover with an erosion control blanket.
 - *PRSC:* Surface water and groundwater monitoring; monitoring and maintenance of vegetation; monitoring and maintenance of physical stability.

7.3.3.2 EFFECTIVENESS

Under this alternative, mine wastes are removed and disposed in an engineered on-site repository. Because wastes are isolated from the environment, this alternative is highly effective in controlling future migration of contaminants. The repository cap and liner system are the key design elements that isolates wastes from the environment. The cap provides a barrier that minimizes direct infiltration of precipitation into the waste, and therefore, minimizes the amount of leachate that is generated within the waste. The bottom liner minimizes the seepage of leachate through the bottom of the repository, resulting in a low volume of leachate.

❖ REMOVAL ACTION OBJECTIVES

Removal of mine wastes to an on-site repository would meet RAOs to the maximum extent.

❖ OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

There are no identified unacceptable human health risks remaining at the dump sites in the Miller Creek Valley. Alternative MC-3 would provide maximum protection to the environment because contaminants would no longer be present at uncontrolled sites.

❖ COMPLIANCE WITH ARARS

Compliance with ARARs may not be fully achieved under Alternative MC-3, even when combined with sediment control from roadways, without other cleanup actions that address cleanup of natural sediment sources that include the barren slopes with anomalously high metals concentrations on the southwest flank of Henderson Mountain. Under current conditions, the exceedance of water quality

standards principally occurs during high flow events (with the exception of copper), which strongly suggests that contaminants are associated with sediment transported in surface waters. Some improvement in water quality in Miller Creek is expected, however, because erosion of contaminants from the removed waste dump areas would be eliminated.

Groundwater quality in the Miller Creek drainage has been measured in only three wells and varies considerably. The two wells located in the upper Miller Creek drainage (MW-5P, a bedrock well; and 5A, an alluvial well), are in compliance with groundwater quality standards in both the shallow alluvial aquifer and the bedrock well completed in the Wolsey Shale in the Crown Butte Fault Zone. The other well (MW-6) is located immediately down gradient of the Alice E Pit and dump complex and exceeds the standards for arsenic, cadmium, lead, and manganese (one sample event only). Removal of mine waste dumps and sediment control from roadways will likely have no effect on groundwater. The Alice E Pit and waste rock dumps are located on private land and because of this are not considered for reclamation activities in this EECA, and therefore there will be no significant change in degraded groundwater quality immediately below this mine site.

Contaminant-specific ARARs for ambient air are expected to be met under this alternative because the wastes will be capped in an engineered repository and the repository and removal areas revegetated. Although dust and problems with PM-10 airborne contaminants have not been investigated, air quality should improve to some extent because the unvegetated dumps will be removed.

Location-specific ARARs at the dump removal sites are expected to be met to a substantial degree. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash; backfilling collapsed adits; and, removing mine dumps. Historic structures and debris located adjacent to the dumps (like that at the Little Daisy Mine and Mill site and at the Black Warrior Mine) will be protected. Historic structures and debris that can be easily salvaged will be moved off the dumps and protected to represent elements of the former mining features. Requirements of the National Historic Preservation Act and the Archaeological and Historic Preservation Act will be met through consultation with the State Historic Preservation Office by the USDA-FS, and mitigation of cultural and historic impacts on the District as a whole.

Threatened and endangered species are present in or near the District. The U.S. Fish and Wildlife Service has identified the grizzly bear, bald eagle, Canada lynx, and gray wolf as threatened and endangered species that may be present in the project area. No critical habitat was designated or proposed in the project area, although the District lies within the Grizzly Bear Recovery Zone for the Yellowstone area. Long-term impacts to threatened and endangered species from the proposed action are not expected, although risk to grizzly bear mortality may be higher due to the increased use of the area. Also, displacement of wildlife species such as the grizzly bear may be increased by reclamation activities in the short-term.

Although construction and implementation of the alternative will require an increased level of activity, long-term maintenance will not require a level of activity that is greater than that existing under current conditions. In the long term, mitigation of mining-related water quality impacts in the District should serve to enhance wildlife habitat by removing contaminants from the environment. The overall impact of response and restoration activities is neutral to beneficial to wildlife, although road improvements that are being done over the life of the project could have long-term impacts on wildlife due to increased traffic, increased traffic speeds, and increased use of the area.

Other location-specific ARARs at the dump removal sites will be protected through substantive compliance with the requirements of laws related to streambeds, floodplains, and wetlands. The Floodplain and Floodway Management Act will be complied with because removals will not be conducted in a designated 100-year floodplain. The Natural Streambed and Land Preservation Act will be complied with at those sites where wastes are in contact with surface water. Affected areas will be reconstructed with earth and natural materials and sufficiently protected with erosion control techniques so that the bed and banks are protected from erosion. Protecting wetlands will be accomplished by avoiding, to the extent possible, adverse impacts to wetlands.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with through the use of best management practices (BMPs) at the removal areas and at the repository.

It should be noted that mine and mill wastes are excluded from regulation under the Montana Solid Waste Management Act (75-10-214 (1)(b) MCA. Substantive requirements of this act are met at the repository site through siting and design criteria. Also, because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 et seq.

Revegetation requirements contained in the Surface Mining Control and Reclamation Act, Montana Strip and Underground Mine Reclamation Act and Metal Mining Act would be substantively met by grading, backfilling, and topsoiling removal areas, and using primarily native species and matching species to surrounding habitat types. BMPs for seeding, planting, mulching, soil amendments, control of noxious weeds, and erosion control will also be followed under this alternative.

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using best management practices (BMPs).

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

❖ LONG-TERM EFFECTIVENESS AND PERMANENCE

Removing the wastes from current locations should be a permanent solution requiring little maintenance and providing long-term effectiveness at the waste sites. PRSC involving monitoring and maintenance will be done at the removal areas. Monitoring and maintenance will improve the chances for achieving long-term effectiveness.

❖ REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

There will be a considerable reduction in mobility but no reduction of toxicity or volume if on-site disposal is implemented. Reduction in the mobility of the contaminants would be achieved by removing wastes to a repository

❖ SHORT-TERM EFFECTIVENESS

This removal action should be completed in a single construction season of not more than 90 days. Therefore, impacts associated with construction activities are considered short-term, and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

The major short-term impact to the surrounding community, residents, and wildlife involves increased vehicle traffic, road building and upgrade work associated with access to the mine sites, clearing ground for a repository, and temporary closures of some forest roads. An increase in traffic will occur during mobilization and demobilization of construction equipment.

Short-term road closures in the project area may be necessary, limiting access to the forest. To haul the waste to the repository, about 150 round-trip truck trips (25 m³/truck) will be made on the Daisy Pass Road and the upper connecting road between the Daisy Pass and Lulu Pass roads. Increased traffic may impact wildlife by either changing daily migration patterns or exposing wildlife to a higher potential for injury or death due to collisions with vehicles.

Short-term air quality impacts to the immediate environment may occur during excavation and placement of wastes and development of access roads. Control of fugitive dusts may thus require the use of best management practices. Dust control on designated haul routes is an expected requirement.

Road improvements needed to implement this alternative may have some short-term impacts on the watershed. Increased sedimentation may result from road improvements due to an increased sediment load from exposures in widened roads and deeper and wider borrow ditches. Implementing best management practices for storm water runoff will mitigate these impacts.

7.3.3.3 IMPLEMENTABILITY

Removal of wastes to an on-site repository is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available. Availability of these items will allow the timely implementation and successful execution of the alternative.

7.3.3.4 COST

A summary of the total estimated costs for Alternatives MC-3 is shown in **Table 7-5**. The detailed cost analysis is contained in Appendix D.

TABLE 7-5
SUMMARY OF TOTAL ESTIMATED COSTS FOR MILLER CREEK ALTERNATIVE MC-3
New World Mining District Response and Restoration Project
Miller Creek Response Action EE/CA

Item	Estimated Cost (\$)
EXCAVATE, HAUL, AND PLACE WASTE	
Upgrade Access Roads	\$47,384
Clear and Grub	\$5,152
Excavate Load and Haul and Compact Waste (3,622 m ³ , with 15% swell)	\$66,853
Regrade Removal Areas	\$3,321
Revegetate Removal Areas	\$35,031
Drainage Channels	\$27,000
Erosion Control	\$3,830
Reclaim Access Roads	\$34,592
Waste Spreading, Grading and Compaction (with over excavation)	\$16,204
Subtotal Excavate, Haul and Place Waste	\$239,369
REPOSITORY COSTS	\$474,547
Subtotal Work Tasks	\$713,916
Mobilization (10%):	\$71,391
Contingency (12%):	\$85,669
TOTAL CONSTRUCTION ESTIMATE:	\$870,977
Ancillary Actions	
Road Rehabilitation	\$558,193
Glengarry Wetlands	\$97,400
Cumberland Dump Debris Cleanup	\$11,965
Subtotal Ancillary Actions	\$667,558
Engineering Evaluation and Design (8%):	\$ 123,082
Construction Oversight (5%):	\$ 76,927
Present Worth Post-Removal Site Control Estimate:	\$54,759
TOTAL ESTIMATED COST	\$1,793,305

8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the alternatives evaluated in detail in Section 7.0. The comparative analysis is performed for each of the three primary criteria, effectiveness, implementability, and cost. A preferred alternative is also identified at the end of the section.

8.1 EFFECTIVENESS

Overall, *in-situ* reclamation (Alternative MC-2) would be effective in providing suitable soil conditions for revegetation in the short-term, and a corresponding reduction in mobility of metal contaminants. However, because site conditions limit the depth of waste treatment, untreated wastes will remain at the sites. Under certain conditions, generally during moderate to extreme weather or periods of high runoff, untreated wastes could become saturated and release contaminants to the environment. There is also the potential for the treated surface of the waste to reacidify due to capillary rise of acid from underlying untreated wastes, resulting in a reduction in vegetation cover and vigor. Such a mechanism would likely cause the waste dump to revert to pre-treatment conditions.

Surface controls implemented as part of *in-situ* reclamation (Alternative MC-2) would be effective in reducing impacts that result from surface water run-on encountering waste. Diversion of run-on at dumps where this problem occurs is a simple, straight-forward approach to reducing mobility of contaminants.

Alternative MC-3, total removal of District Property waste dumps, is the most effective of the alternatives considered. The No Action Alternative does not address surface water impacts, nor does it provide any controls on contaminant migration.

8.1.1 Removal Action Objectives

Alternative MC-3, total removal, meets most RAOs because wastes are removed and placed in a controlled repository with leachate collection. Alternative MC-2, *in-situ* reclamation, meets the RAOs to some extent. Revegetating the waste dumps will greatly reduce the amount of soluble metals that can migrate from the dumps to surface water. Soluble metals will not be eliminated because some portion of the wastes in the dump will remain untreated and in contact with infiltrating precipitation. The RAO of reducing or eliminating concentrated runoff and sediment discharges will be met through regrading and rerouting of surface water at the sites. No action meets one of the RAOs -- preserving the existing undeveloped character of the District and surrounding area.

8.1.2 Overall Protection of Human Health and the Environment

The Black Warrior is only waste dump on District Property that poses a risk to human health. There are no identified unacceptable human health risks associated with the average concentration of metals present in waste at other mine sites in Miller Creek. *In-situ* reclamation (Alternative MC-2) greatly reduces human health risk by providing a vegetated surface on the waste dumps. Removing the Black Warrior dump (Alternative MC-3) would eliminate human health risk on District Property in Miller Creek entirely.

The greatest risk to the environment comes from degraded surface water and groundwater quality and its impact to aquatic life. Vegetated surfaces will reduce the potential for further erosion and migration of contaminants from source areas by stabilizing metal-rich soils, resulting in a reduction in sediment transport in Miller Creek. Alternative MC-2 is protective of the environment for most of the dump

sites because most of the sites are located a good distance from surface water. This alternative also provides some protection to the environment by addressing diversion of run-on and runoff at sites that directly impact surface water. Again, removal (Alternative MC-3), would virtually eliminate the risks that result directly from mine waste dumps. However, mine waste dumps are not the only source of metals in the Miller Creek watershed, and are not the principal sources contributing metals and sediments to surface water and groundwater. Both alternatives will treat sediments from roadways as an ancillary action, which will minimize impacts to surface water and the environment.

8.1.3 Compliance with ARARs

Alternative MC-3 is the best of the alternatives when evaluating compliance with ARARs. However, neither MC-2 or MC-3 will likely achieve compliance with surface water standards, as mine waste associated with the widely scattered Miller Creek dumps are probably a relatively minor source of direct loading of metals and sediments to Miller Creek. The Black Warrior and Miller Creek Dumps 1 and 2 are probably the greatest mine waste dump contributors to water quality degradation in Miller Creek because these are the only mine waste dumps located proximal to Miller Creek. Sediment from roadways will be also minimized under either of the action alternatives, and implementing either of these alternatives will improve water quality in Miller Creek.

Under Alternative MC-3, removal of the Black Warrior dump will greatly reduce the risk of lead contamination to surface water and stream sediments measured in Miller Creek. The Black Warrior also contains about 22% of the total mine waste present (610/2,810 cubic meters) on District Property in Miller Creek.

Alternative MC-2 will impact threatened and endangered species the least, with Alternative MC-3 having the greatest impact to these concerns. Traffic impacts are greater for Alternative MC-3 because of the greater amount of haul traffic. Both Alternatives MC-2 and MC-3 would require a considerable amount of road building and subsequent reclamation to provide equipment access to the sites for loading and hauling materials. Alternatives MC-2 and MC-3 are expected to meet action-specific and location-specific ARARs equally. The No Action Alternative is the least compliant with ARARs of the alternatives considered.

8.1.4 Long-Term Effectiveness and Permanence

Most of the mine waste dumps included in Miller Creek Source Area are very small and lie at some distance to surface waters. Because the entire package of waste materials at each dump site cannot be fully amended under Alternative MC-2, *in-situ* reclamation may not be a permanent solution and acidity from unamended wastes lying below the amended zone has the potential to move upward to the surface, resulting in the return of the dump to an unvegetated condition. Removing wastes under Alternative MC-3 should be a permanent solution requiring little maintenance and providing long-term effectiveness at the waste sites.

8.1.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

None of the alternatives reduces the volume of contaminants. Alternatives MC-2 reduce the mobility of contaminants to some degree by providing a regraded and vegetated surface, and also through treatment with a neutralizing amendment. Alternative MC-2 also achieves a reduction in plant toxicity through treatment. Alternative MC-3 achieves the greatest reduction in mobility by removing all of the wastes.

8.1.6 Short-Term Effectiveness

Short-term effectiveness of both of the action alternatives considered for the Miller Creek Source Area is similar in that construction will be completed in a single construction season. Short-term impacts associated with Alternatives MC-2 and MC-3 are also similar because road improvements will be required to access the dump sites. Alternative MC-3, total removal, requires the greatest amount of equipment, materials, and time to complete. Alternative MC-3 places more impacts on the local community and roads due to the larger number of truck trips that will be made hauling mine waste and construction materials to the repository site. There are no impacts in the short-term from the No Action Alternative.

8.2 IMPLEMENTABILITY

All of the alternatives are technically and administratively feasible. Essential project components such as equipment, materials, and construction expertise, although distant from the site, are available. Alternative MC-3 requires some specialized construction techniques at the repository, but these techniques are proven and can be implemented at the site. Geomembrane liner installation requires specialized equipment and labor including seam welders and seam test equipment. Quality Assurance/Quality Control for geomembrane liner installation is very strict, requiring experienced personnel and specialized equipment. Liners are available in-state, but available specialized labor may be limited.

8.3 COST

Alternative MC-3, removal of mine waste from District Property sites to an on-site repository, is by far the most expensive of the alternatives evaluated for the Miller Creek Source Area. The total cost to implement this alternative is about \$1.8 million. The estimated cost for Alternative MC-2 is about \$1.1 million. For both Alternatives MC-2 and MC-3, the cost to implement ancillary items is a substantial portion of the total cost of the alternatives. The cost to implement the ancillary items for both alternatives is estimated to be \$668,000. For Alternative MC-2, the cost of in-situ reclamation is about \$222,000. For Alternative MC-3, the estimated cost of removal is \$871,000.

The No Action Alternative is the least expensive of the alternatives because there are no capital costs that will be expended for cleanup. However, there are external costs associated with no action, including the loss of certain ecological functions such as a healthy, viable fishery and aquatic community.

8.4 PREFERRED ALTERNATIVE

The preferred alternative for the Miller Creek response action uses a combination of the alternatives discussed. Except for the Black Warrior Dump, there appears to be little major impact from the 26 mine waste dumps located on District Property in Miller Creek. The Black Warrior is the only human health risk identified, and it also contains about 22% of the total mine waste in the Miller Creek drainage on District Property. Environmental risks appear to be associated with mine waste that is in contact with surface water and/or groundwater. This is the case at the Miller Creek Dumps #1 and #2, which are two dumps located proximal to Miller Creek. Only two other very small dumps sites occur in close proximity to Miller Creek and these are the Miller Creek Dump Four (40 cubic meters, MCSI-00-1) and the Lower Miller Creek Dump One (30 cubic meters, MCSI-96-4).

At the Little Daisy Mine, waste rock sits at the mouth of the adit, and discharge from the adit flows through the dump. The flow continues in the subsurface beneath shallow colluvial and talus material

below the Mine site. This water does not obviously come to surface further down-slope. Impacts to surface water from the Little Daisy Mine outflow and waste rock appear to be only minor. This dump is comparable in size to the Black Warrior containing about 680 cubic meters and 24% of total waste in Miller Creek on District Property,

Other mine waste dumps and their associated mine sites lie topographically well above the valley bottom, in mostly dry locations and present no risk to human health and little threat to surface or groundwater quality (except for brief periods during active precipitation or snowmelt). Because of the nominal nature of recognized impacts from remaining dumps in Miller Creek, the preferred alternative for the Miller Creek Source Area is Alternative MC-2 for the four waste dumps located proximal to Miller Creek. These sites include: Miller Creek Dump One (MCSI-99-72), Miller Creek Dump Two (MCSI-96-1), Miller Creek Dump Four (MCSI-00-1) and Lower Miller Creek Dump One (MCSI-96-4). Alternative MC-3, total removal to the SB-4B(B) repository, is selected for the Black Warrior and Little Daisy dumps. Removing these two dumps to the repository eliminates 46% of the total volume of waste rock present in Miller Creek. The No Action Alternative is selected for the remaining dumps. Ancillary Actions, including road rehabilitation, constructing the Glengarry Mine wetlands, and removing trash from the Cumberland Dump will be completed under the preferred alternative as well.

Table 8-1 presents the cost for the preferred alternative. The cost of removal and disposal of the Black Warrior and Little Daisy dumps to the Selective Source repository is estimated to be \$265,000, which includes road upgrades and repository construction costs. Cost of reclaiming the four selected sites in-situ is estimated to be \$63,400. Adding in the ancillary items, engineering evaluation, design, PRSC, and oversight, the total estimated cost of the preferred alternative is \$1,221,800.

TABLE 8-1 PREFERRED ALTERNATIVE ESTIMATED COST New World Mining District Response and Restoration Project Miller Creek Response Action	
ITEM	ESTIMATED COST
In-situ reclamation (four sites)	\$63,400
Removal of the Black Warrior and Little Daisy Dumps	\$265,400
Natural Resource Restoration	\$667,600
Mobilization/Contingency	\$72,300
Engineering Evaluation/Design/Oversight/PRSC	\$153,100
TOTAL ESTIMATED COST	\$1,221,800

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APPENDIX A

SOURCE AREA SITE FORMS

Miller Creek Response Action EE/CA

New World Mining District Response and Restoration Project

APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Miller Creek Response Action EE/CA

New World Mining District Response and Restoration Project

Applicable or Relevant and Appropriate Requirements (ARARs)

Section 300.415(i) of the National Contingency Plan (NCP) and guidance issued by the EPA require that removal actions attain Applicable or Relevant and Appropriate Requirements (ARARs) under federal or state environmental laws or facility siting laws, to the extent practicable considering the urgency of the situation and the scope of the removal (EPA, 1993). In addition to ARARs, the lead Agency may identify other federal or state advisories, criteria, or guidance to be considered for a particular release. ARARs were identified in the Como Basin/Glengarry Adit/Fisher Creek Response Action EE/CA. .

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant found at a site and would apply in the absence of a CERCLA cleanup. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that are not applicable to a particular situation but apply to similar problems or situations, and therefore may be well suited requirements for a response action to address.

ARARs are divided into contaminant specific, location specific, and action specific requirements. Contaminant specific ARARs are listed according to specific media and govern the release to the environment of specific chemical compounds or materials possessing certain chemical or physical characteristics. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs generally relate to the geographic location or physical characteristics or setting of the site, rather than to the nature of the site contaminants.

Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Only the substantive portions of the requirements are ARARs. Administrative requirements are not ARARs and do not apply to actions conducted entirely on-site. Provisions of statutes or regulations that contain general goals expressing legislative intent but are non-binding are not ARARs. In addition, in instances like the present case where the cleanup is proceeding in stages, a particular phase of the remedy may not comply with all ARARs, so long as the overall remedy does meet ARARs.

Under Section 121 of CERCLA, 42 U.S.C. §9621, only those state standards that are more stringent than any federal standard are considered to be an ARAR provided that these standards are identified by the state in a timely manner. To be an ARAR, a state standard must be "promulgated," which means that the standards are of general applicability and are legally enforceable. The State of Montana ARARs set forth below have been identified in cooperation with, and with assistance from, the State of Montana Department of Environmental Quality.

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
FEDERAL CONTAMINANT-SPECIFIC			
<u>Safe Drinking Water Act</u>	40 USC § 300		
National Primary Drinking Water Regulation	40 CFR Part 141	Establishes health-based standards (MCLs) for public water systems.	Relevant and Appropriate
National Secondary Drinking Water Regulations	40 CFR Part 143	Establishes welfare-based standards (secondary MCLs) for public water systems.	Relevant and Appropriate
<u>Clean Water Act</u>	33 USC. §§ 1251-1387	Ch. 26- Water Pollution Prevention & Control	
Water Quality Standards	40 CFR Part 131 Quality Criteria for Water 1976, 1980, 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate
FEDERAL LOCATION-SPECIFIC			
<u>National Historic Preservation Act</u>	16 USC § 470; 36 CFR Part 800; 40 CFR Part 6.310(b)	Requires Federal Agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly affected by an undertaking.	Applicable
<u>Archaeological and Historic Preservation Act</u>	16 USC § 469; 40 CFR § 6.301(c)	Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
<u>Historic Sites, Buildings and Antiquities Act</u>	36 CFR § 62.6(d)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Applicable
<u>Protection of Wetlands Order</u>	40 CFR Part 6	Avoid adverse impacts to wetlands.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
<u>Migratory Bird Treaty Act</u>	16 USC §§ 703 <u>et seq.</u>	Establishes a federal responsibility for the protection of international migratory bird resource.	Applicable
FEDERAL LOCATION-SPECIFIC (continued)			
<u>Fish and Wildlife Coordination Act</u>	16 USC § 661 <u>et seq.</u> ; 40 CFR Part 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources.	Applicable
<u>Floodplain Management Order</u>	40 CFR Part 6	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain, to the extent possible.	Relevant and Appropriate
<u>Bald Eagle Protection Act</u>	16 USC §§ 668 <u>et seq.</u>	Establishes a federal responsibility for protection of bald and golden eagles. Requires consultation with the USFWS.	Applicable
<u>Endangered Species Act</u>	16 USC §§ 1531-1543; 40 CFR Part 6.302(h); 50 CFR Part 402	Requires action to conserve endangered species within critical habitat upon which species depend. Includes consultation with Dept. of Interior.	Applicable
FEDERAL ACTION-SPECIFIC			
<u>Clean Water Act</u>	33 USC §§ 1251-1387	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and Appropriate
National Pollutant Discharge Elimination System	40 CFR Parts 121, 122, 125		
<u>Clean Air Act</u> National Primary and Secondary Ambient Air Quality Standards	42 USC § 7409;40 CFR Part 50.12	Air quality levels that protect public health.	Applicable
<u>Surface Mining Control and Reclamation Act</u>	30 CFR Parts 816, 784	Reclamation requirements for coal and certain non-coal mining.	Not Applicable
<u>Resource Conservation and Recovery Act</u>	42 USC § 6901	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270 and 271.	Not Applicable

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
	40 CFR Part 258.6, 258.61	Governs cover requirements	Relevant and Appropriate
	40 CFR Part 264.228	Provisions regarding run-on and run-off controls	Relevant and Appropriate
FEDERAL ACTION-SPECIFIC (continued)			
<u>Occupational Safety And Health Act</u>	29 USC § 655	Defines standards for employee protection during initial site characterization and analysis, monitoring activities, materials handling activities, training & ER.	Applicable
Hazardous Waste Operations And Emergency Response	29 CFR 1910.120		
STATE CONTAMINANT-SPECIFIC			
<u>Montana Water Quality Act</u>	75-5-101 <u>et seq.</u> , MCA	Establishes Montana's laws to prevent, abate and control the pollution of state waters.	Applicable
	ARM 17.30.601 <u>et seq.</u>	Provides the water use classification for various streams and imposes specific water quality standards per classification.	Applicable
Regulations Establishing Ambient Surface Water Quality Standards	<u>ARM 17.30.637</u>	Provides that surface waters must be free of substances attributable to industrial practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film or globules of grease or other floating materials; (c) produce odors, colors, or other conditions which create a nuisance or render undesirable tastes to fish or make fish in edible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Groundwater Pollution Control System Regulations	ARM 17.30.1011	Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to state water	Not Applicable
	ARM 17.30.1006	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and states groundwater is to be classified to actual quality of actual use, whichever places the groundwater in a higher class.	Applicable
STATE CONTAMINANT-SPECIFIC (continued)			
<u>Clean Air Act Of Montana</u>	75-2-101, MCA	Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	Applicable
	ARM 17.8.206	Establishes sampling, data collection, and analytical requirements to ensure compliance with ambient air quality standards.	Applicable
	ARM 17.8.222	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 17.8.220	No person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter.	Applicable
	ARM 17.8.223	No person may cause or contribute to concentrations of PM-10 in the ambient air which exceed the following standards: 1) 24-hr. avg. : 150 micrograms per cubic meter of air, with no more than one expected exceedance per year; 2) Annual avg.: 50 micrograms per cubic meter of air.	Applicable
<u>Occupational Health Act of Montana</u>	50-70-101, et. seq., MCA	The purpose of this act is to achieve and maintain such conditions of the work place as will protect human health and safety	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Occupational Air Contaminants Regulations	ARM 17.42.102	Establishes maximum threshold limit values for air contaminants believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.	Applicable
	ARM 17.42.101	Addresses occupational noise levels and provides that no worker should be exposed to noise levels in excess of the specified levels.	Applicable
Occupational Noise Regulations			
STATE LOCATION-SPECIFIC			
<u>Floodplain and Floodway Management Act</u>	76-5-401, MCA	Lists the uses permissible in a floodway and generally prohibits permanent structures, fill, or permanent storage of materials or equipment.	Applicable
	76-5-402 MCA	Lists the permissible permanent structures that are allowed in the floodplain excluding the floodway, if they are permitted and meet certain minimum standards.	Applicable
	76-5-403, MCA	Lists certain uses which are prohibited in a designated floodway, including any change that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway, or the concentration or permanent storage of an object subject to flotation or movement during flood level periods.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Floodplain Management Regulations	ARM 36.15.216	The factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway are set forth in this section.	Applicable
	ARM 36.15.602	Specifies uses requiring permits for allowing obstructions in the floodway.	Applicable
	ARM 36.15.603	Proposed diversions or changes in place of diversions must be evaluated by the DNRC to determine whether they may significantly affect flood flows and, therefore, require a permit.	Applicable
	ARM 36.15.604	Prohibits new artificial obstructions or nonconforming uses that will increase the upstream elevation of the base flood 0.5 of a foot or significantly increase flood velocities.	Applicable
STATE LOCATION-SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
<u>Floodplain Management Regulations</u> (continued)	ARM 36.15.605	Identifies artificial obstructions and nonconforming uses that are prohibited within the designated floodway except as allowed by permit and includes "a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway..." Solid waste disposal and storage of highly toxic, flammable, or explosive materials are also prohibited.	Applicable
	ARM 36.15.606	Identifies flood control works that are allowed with designated floodways pursuant to permit and certain conditions including: flood control levies and flood walls, rip rap, channelization projects, and dams.	Not Applicable
	ARM 36.15.701 and 703	Describes allowed uses in the flood fringe. Prohibited uses within the flood fringe (i.e., areas in the floodplain, but outside of the designated floodway) areas including solid waste disposal and storage of highly toxic, flammable or explosive material.	Applicable
	ARM 36.15.801	Allowed uses where floodway is not designated.	Applicable
<u>Montana Solid Waste Management Act and Regulations</u>	75-10-201, MCA ARM 17.50.505	Specifies the requirements that apply to the location of any solid waste management facility.	Applicable
<u>Endangered Species</u>	87-5-106, 107,111, MCA ARM 12.5.201	Fish and wildlife resources are to be protected and no construction project or hydraulic project shall adversely affect game or fish habitat.	Applicable
STATE LOCATION SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
<u>Natural Streambed and Land Preservation Act</u>	75-7-101, <u>et seq.</u> , MCA	The adverse affects of any action shall minimize alteration or affects to a streambed or its banks	Applicable
Natural Streambed and Land Preservation Standards	ARM 36.2.404, 405, 406, and 410	Proposed projects are to be evaluated by the appropriate conservation district based on criteria including: 1) whether the project will pass anticipated sediment loads without creating harmful flooding or erosion problems upstream or downstream; 2) whether the project will minimize the amount of stream channel alteration; 3) whether the project will be as permanent a solution as possible and whether the method used will create a reasonably permanent and stable situation; 4) whether the project will minimize effects of fish and aquatic habitat; 5) whether the project will minimize turbidity or other water pollution problems; and, 6) whether the project will minimize adverse effects on the natural beauty of the area	Applicable
STATE ACTION SPECIFIC			
<u>Montana Water Quality Act</u>	75-5-605, MCA	Pursuant to this section, it is unlawful among other things, to cause pollution of any state waters, to place any wastes in a location where they are likely to cause pollution of any state waters, to violate any permit provision, to violate any provision of the Montana Water Quality Act, to construct, modify, or operate a system for disposing of waste (including sediment, solid waste and other substances that may pollute state waters) which discharge into any state waters without a permit or discharge waste into any state waters.	Applicable
MPDES Permit Requirements	ARM17.30.1342-1344	Sets forth the substantive requirements applicable to all MPDES and NPDES permits. Include the requirement to properly operate and maintain all facilities and systems of treatment and control.	Not Applicable
	ARM 17.30.1203 and 1344	Technology-based treatment for MPDES permits.	Not Applicable
STATE ACTION-SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Nondegradation of Water Quality	75-5-303, MCA	States that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected. Provides exemption that allows changes of existing water quality resulting from emergency or remedial activity designed to protect the public health or the environment.	Not Applicable
	ARM 17.30.705	Provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed.	Not Applicable
	ARM 17.30.1011	Requires that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with 75-5-303, MCA and ARM 17.30.701, <u>et seq.</u>	Not Applicable
<u>Clean Air Act Of Montana</u>	75-2-102, MCA	Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	Applicable
Air Quality Requirements	ARM 17.8.308	No person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.	Applicable
	ARM 17.8.604	Lists certain wastes that may not be disposed of by open burning.	Applicable
	ARM 17.8.1401-1404	Sets forth emission standards for hazardous air pollutants	Applicable
<u>Montana Solid Waste Management Act</u>	75-10-201, <u>et seq.</u> , MCA	Public policy is to control solid waste management systems to protect the public health and safety and to conserve natural resources whenever possible.	Relevant and Appropriate
STATE ACTION-SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Solid Waste Management Regulations	ARM 17.50.505 and 508-509	The standards for solid waste disposal are set forth in this provision.	Not Applicable
	ARM 17.50.511	General operational and maintenance requirements for solid waste management systems are established pursuant to this section. This section requires that solid waste disposal be confined to areas within the disposal site that can be effectively maintained and operated.	Not Applicable
	ARM 17.50.523	Solid waste must be transported In such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.	Relevant and Appropriate
Montana Hazardous Waste And Underground Storage Tank Act	75-10-401, <u>et seq.</u> , MCA	State's policy to protect the public health and safety, the health of living organisms, and the environment from the effects of the improper, inadequate, or unsound management of hazardous wastes.	Not Applicable
Montana Hazardous Waste Regulations	ARM 17.54.701-703	By reference to federal regulatory requirements, these sections establish standards for all permitted hazardous waste management facilities.	Not Applicable
		1) 40 CFR 264.111 (referenced by ARM 17.54.720) establishes that hazardous waste facilities must be closed in such a manner as to minimize the need for further maintenance and control, minimize or eliminate, to the extent necessary to protect public health and the environment, post closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or the atmosphere. Such closure must comply with the closure requirements of 40 CFR 264 Subpart G.	Not Applicable
STATE ACTION-SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Hazardous Waste Regulations (continued)	ARM 17.54.701-703 (continued)	2) 40 CFR 264.228(a)(2) (incorporated by reference by ARM 17.54.702) requires that at closure, free liquids must be removed or solidified, the wastes stabilized and the wastes management unit covered	Not Applicable
		3) 40 CFR 264.228(a)(2) and 310 (incorporated by reference in ARM 17.54.702) requires that surface impoundments and landfill caps must: (a) provide long-term minimization of migration of liquids through the unit; (b) function with minimum maintenance; (c) promote drainage and minimize erosion or abrasion of the final cover; (d) accommodate settling and subsidence; and (e) have a permeability less than or equal to the permeability of the natural subsoils present.	Not Applicable
		4) 40 CFR 264.228 and 310 (incorporated by reference in ARM 17.54.702) requires that a map be provided showing the dimensions of waste disposal units, together with the types and amounts of waste disposed of in each unit. Additionally, the owner must record a deed restriction, in accordance with state law, that will in perpetuity notify potential purchasers that the property has been used for waste disposal and that its use is restricted.	Not Applicable
	ARM 17.54.109-113	Establishes permit conditions, duration of permits, schedules.	Not Applicable
<u>Montana Strip and Underground Mine Reclamation Act</u>	82-4-231, MCA	Sets forth objectives that require the operator to prepare and carry out a method of operations plan to reclaim and revegetate the land affected by his operation	Relevant and Appropriate
	82-4-233, MCA	Requires that after the operation has been backfilled, graded, topsoiled and approved, the operator shall establish a vegetative cover on all impacted lands. Specifications for the vegetative cover and performance are provided.	Relevant and Appropriate
STATE ACTION-SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Backfilling and Grading Requirements	ARM 17.24.501	Gives general backfilling and grading requirements.	Relevant and Appropriate
	ARM 17.24.504	Provides that permanent impoundments may be retained under certain circumstances.	Not Applicable
	ARM 17.24.514	Gives contouring requirements.	Relevant and Appropriate
	ARM 17.24.519	Operator may be required to monitor settling of regraded areas.	Not Applicable
	ARM 17.24.520	Spoil material may be disposed of on-site in accordance with requirements of this section. Contains specific requirements for siting, surface runoff, construction of underdrains and revegetation.	Not Applicable
Hydrology Requirements	ARM 17.24.631	Reclamation operations must be planned and conducted to minimize disturbance and prevent damage to the prevailing hydrologic balance.	Relevant and Appropriate
	ARM 17.24.633	Specifies that sediment controls must be maintained until the disturbed area has been restored and revegetated.	Relevant and Appropriate
	ARM 17.24.634	Drainage design shall emphasize premining channel and floodplain configurations that blend with the undisturbed drainage system above and below; will meander naturally; remain in dynamic equilibrium with the system; improve unstable premining conditions, provide for floods, provide for long term stability of the landscape; and establish a premining diversity of aquatic habitats and riparian vegetation.	Relevant and Appropriate
	ARM 17.24.635-637	Sets forth requirements for temporary and permanent diversions.	Relevant and Appropriate
	ARM 17.24.641	Sets methods for preventing drainage from acid-and toxic-forming wastes into ground and surface waters.	
			Relevant and

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status Appropriate
STATE ACTION-SPECIFIC (continued)			
Hydrology Requirements (continued)	ARM 17.24.642	Prohibits permanent impoundments with certain exceptions, and sets standards for temporary and permanent impoundments.	Not Applicable
	ARM 17.24.643-646	Provides for groundwater and groundwater recharge protection, and surface and groundwater monitoring.	Not Applicable
	ARM 17.24.650	All permanent sedimentation ponds, diversions, impoundments, and treatment facilities must be renovated postmining and regraded to the approximate original contour.	Not Applicable
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations	ARM 17.24.701-702	Requirements for stockpiling soil.	Not Applicable
	ARM 17.24.703	Materials other than, or along with, soil for final surfacing of spoils or other disturbances must be capable of supporting the approved vegetation and postmining land use.	Relevant and Appropriate

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
	ARM 17.24.711	The section requires "a diverse, effective, and permanent vegetative cover of the same seasonal utility native to the area of and to be affected and capable of meeting the criteria set forth in 82-4-233 shall be established on all areas of land affected except water areas and surface areas of roads."	Not Applicable
	ARM 17.24.713	Specifies that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation; but not longer than 90 days after top soil placement.	Relevant and Appropriate
	ARM 17.24.714	According to this section, as soon as practical, a mulch or cover crop must be used on all regraded and resoiled areas to control erosion, to promote germination of seeds, and to increase moisture retention of soil until permanent cover is established.	Relevant and Appropriate
	ARM 17.24.716	Establishes methods of revegetation	Relevant and Appropriate
STATE ACTION-SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 17.24.717	Relates to the planting of trees and other woody species to establish a diverse, effective, and permanent vegetative cover.	Not Applicable
	ARM 17.24.718	Soil amendments must be used as necessary to aid in the establishment of permanent vegetation; irrigation, management, fencing, or other measures may also be used after review and approval by the dep't.	Relevant and Appropriate
	ARM 17.24.719	Livestock grazing on reclaimed land is prohibited until revegetation is established and can sustain managed grazing.	Not Applicable
	ARM 17.24.720	Sets annual department inspection requirements.	Not Applicable
	ARM 17.24.721	Section specifies that rills and gullies greater than 9 inches which form on the reclaimed area may need to be filled, graded or otherwise stabilized and the area reseeded or replanted.	Not Applicable
	ARM 17.24.723	Monitoring of vegetation, soils and wildlife.	Not Applicable
	ARM 17.24.724	Success of revegetation shall be measured on the basis of unmined reference areas.	Not Applicable
	ARM 17.24.725	Sets periods of responsibility and evaluation.	Not Applicable
	ARM 17.24.726	Sets means of measuring productivity.	Not Applicable
	ARM 17.24.728	Sets requirements for composition of vegetation.	Not Applicable
	ARM 17.24.730-731	Revegetated area must furnish palatable forage in comparable quantity and quality during the same grazing period as the reference area.	Not Applicable
STATE ACTION-SPECIFIC (continued)			

Identification of Applicable or Relevant and Appropriate Requirements Miller Creek Response Action			
Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 17.24.733	Sets requirements and measurement standards for trees, shrubs and half-shrubs.	Not Applicable
	ARM 17.24.751	Required site activities must be conducted so as to avoid or minimize impacts to important fish and wildlife species, including critical habitat and any threatened or endangered species identified at the site.	Relevant and Appropriate
	ARM 17.24.761	Section requires fugitive dust control measures for site preparation and reclamation operations.	Relevant and Appropriate

APPENDIX C

**ROAD REHABILITATION COSTS BY DRAINAGE BASIN AND WORK
ELEMENT**

*Miller Creek Response Action EE/CA
New World Mining District Response and Restoration Project*

**NATURAL RESOURCE RESTORATION
COST SUMMARY**

CATEGORY	ROAD TYPE	DRAINAGE	COST	TOTAL COST
Road Closures	Reclamation Type 1 Roads	DAISY	\$ 18,523.62	
		FISHER	\$ 65,504.12	
		MILLER	\$ 124,965.34	
		SODA BUTTE	\$ 18,089.17	
		ROSEBUD	\$ 710.93	
		Total		\$ 227,793.18
Restricted Use	Administrative Closure Type 4 Road	DAISY	\$ 2,000.00	
		Total		\$ 2,000.00
	Restricted Width Type 3 Roads	DAISY	\$ 11,275.25	
		FISHER	\$ 18,329.50	
		MILLER	\$ 29,453.38	
		SODA BUTTE	\$ 24,531.50	
		ROSEBUD	\$ 157.50	
	Total		\$ 83,747.13	
	Road Upgrades	Drain + Leave Open Type 2 Roads	DAISY	\$ 30,367.63
FISHER			\$ 51,616.81	
MILLER			\$ 9,293.38	
SODA BUTTE			\$ 26,486.69	
ROSEBUD			\$ -	
Total				\$ 117,764.50
Improve Drainage Type 5 Roads		DAISY	\$ 25,012.50	
		FISHER*	\$ 26,842.88	
		MILLER	\$ 59,657.88	
		SODA BUTTE	\$ 5,375.13	
		ROSEBUD	\$ -	
		*SPECIAL	\$ 10,000.00	
Total			\$ 126,888.38	
PROJECT TOTAL				\$ 558,193.18
DAISY CREEK		\$ 87,179.00		
FISHER CREEK		\$ 172,293.30		
MILLER CREEK		\$ 223,369.97		
SODA BUTTE		\$ 74,482.48		
ROSEBUD		\$ 868.43		
TOTAL		\$ 558,193.18		

**NATURAL RESOURCE RESTORATION
DAISY CREEK ROAD COST ESTIMATE**

CATEGORY	ROAD TYPE	TASK	Cost/km	km	Cost	Equipment
Road Closure	Reclamation Type 1 Roads	Recontour	\$6,560.00	0.938	\$6,153.28	Tracked Excavator
		fertilizer	\$300.00	0.938	\$281.40	
		seed	\$128.00	0.938	\$120.06	Support Truck
		erosion blanket	\$10,000.00	0.938	\$9,380.00	
		labor	\$2,760.00	0.938	\$2,588.88	3 - ATV
		Total	\$19,748.00	Subtotal	\$18,523.62	
Restricted	Administrative Closure Type 4 Road	Gate, installed		Subtotal	\$2,000.00	
	Restricted Width Type 3 Roads	drainage control	incl.	1.07		Trail builder (hoe)
		water bars	incl.	1.07		ATV
		12"x12' culverts	incl.	1.07		Support Truck
		spot stabilization	incl.	1.07		
		subtotal	\$4,375.00	1.07	\$4,681.25	
		slope revegetation		0.55 ha only	\$6,594.00	
			Subtotal	\$11,275.25		
Road Upgrades	Drain + Leave Open Type 2 Roads	spot surfacing	\$4,687.50	2.702	\$12,665.63	Trail builder (hoe)
		turnpiking	incl.	2.702		Tracked Excavator
		revegetation	\$1,000.00	2.702	\$2,702.00	ATV
		First 1 km		1 km	\$15,000.00	Support Truck
		Henderson Mtn. Rd.				
				Subtotal	\$30,367.63	
	Improve Drainage Type 5 Roads	ditch relief	\$4,375.00	2.1	\$9,187.50	Tracked Excavator
		culverts	\$1,250.00	2.1	\$2,625.00	Tracked Excavator
		rock check dams & sediment traps		incl.		ATV
		heavy treatment		incl.	incl.	Support Truck
		slope revegetation				
		fill slope		1.0	\$13,200.00	
				Subtotal	\$25,012.50	
	DAISY CREEK TOTAL					\$87,179.00

**NATURAL RESOURCE RESTORATION
FISHER CREEK ROAD COST ESTIMATE**

CATEGORY	ROAD TYPE	TASK	Cost/km	km	Cost	Equipment
Road Closures	Reclamation Type 1 Roads	Recontour	\$6,560.00	3.317	\$21,759.52	Tracked Excavator
		fertilizer	\$300.00	3.317	\$995.10	
		seed	\$128.00	3.317	\$424.58	Support Truck
		erosion blanket	\$10,000.00	3.317	\$33,170.00	
		labor	\$2,760.00	3.317	\$9,154.92	3 - ATV
		Total	\$19,748.00	Subtotal	\$65,504.12	
Restricted Use	Restricted Width Type 3 Roads	drainage control	incl.	3.324		Trail builder (hoe)
		water bars	incl.	3.324		
		12"x12' culverts	incl.	3.324		ATV
		spot stabilization	incl.	3.324		Support Truck
		subtotal	\$4,375.00	3.324	\$14,542.50	
		slope revegetation		0.25 ha only	\$3,787.00	
Road Upgrades	Drain + Leave Open Type 2 Roads			Subtotal	\$18,329.50	
		spot surfacing	\$4,687.50	5.559	\$26,057.81	Trail builder (hoe)
		turnpiking	incl.	5.559		Tracked Excavator
		revegetation	\$1,000.00	5.559	\$5,559.00	
		First 1768 m		1.8 km	\$20,000.00	ATV
						Support Truck
				Subtotal	\$51,616.81	
	Improve Drainage Type 5 Roads	ditch relief	\$4,375.00	0.083	\$363.13	Tracked Excavator
		culverts	\$1,250.00	0.083	\$103.75	Tracked Excavator
		rock check dams &		incl.		
		sediment traps		incl.		ATV
		heavy treatment		incl.		Support Truck
		slope revegetation				
		fill slope		1.5 ha only	\$19,782.00	
		downslope spots		0.5 ha only	\$6,594.00	
				Subtotal	\$26,842.88	
Special	Fisher Creek Road				\$10,000.00	
FISHER CREEK TOTAL					\$172,293.30	

**NATURAL RESOURCE RESTORATION
MILLER CREEK ROAD COST ESTIMATE**

CATEGORY	ROAD TYPE	TASK	Cost/km	km	Cost	Equipment
Road Closures	Reclamation Type 1 Roads	Recontour	\$6,560.00	6.328	\$41,511.68	Tracked Excavator
		fertilizer	\$300.00	6.328	\$1,898.40	
		seed	\$128.00	6.328	\$809.98	Support Truck
		erosion blanket	\$10,000.00	6.328	\$63,280.00	
		labor	\$2,760.00	6.328	\$17,465.28	3 - ATV
		Total	\$19,748.00	Subtotal	\$124,965.34	
Restricted Use	Restricted Width Type 3 Roads	drainage control	incl.	5.225		Trail builder (hoe)
		water bars	incl.	5.225		
		12"x12' culverts	incl.	5.225		ATV
		spot stabilization	incl.	5.225		Support Truck
		subtotal	\$4,375.00	5.225	\$22,859.38	
		slope revegetation		0.55 ha only	\$6,594.00	
				Subtotal	\$29,453.38	
Road Upgrades	Drain + Leave Open Type 2 Roads	spot surfacing	\$4,687.50	1.634	\$7,659.38	Trail builder (hoe)
		turnpiking	incl.	1.634		Tracked Excavator
		revegetation	\$1,000.00	1.634	\$1,634.00	
						ATV
						Support Truck
				Subtotal	\$9,293.38	
	Improve Drainage Type 5 Roads	ditch relief	\$4,375.00	4.139	\$18,108.13	Tracked Excavator
		culverts	\$1,250.00	4.139	\$5,173.75	Tracked Excavator
		rock check dams &		1 km only	\$10,000.00	
		sediment traps		incl.		ATV
		heavy treatment		incl.		Support Truck
		slope revegetation				
		fill slope		1.5 ha only	\$19,782.00	
		downslope spots		0.5 ha only	\$6,594.00	
			Subtotal	\$59,657.88		
MILLER CREEK TOTAL					\$223,369.97	

**NATURAL RESOURCE RESTORATION
SODA BUTTE CREEK ROAD COST ESTIMATE**

CATEGORY	ROAD TYPE	TASK	Cost/km	km	Cost	Equipment
Road Closures	Reclamation Type 1 Roads	Recontour	\$6,560.00	0.916	\$6,008.96	Tracked Excavator
		fertilizer	\$300.00	0.916	\$274.80	
		seed	\$128.00	0.916	\$117.25	Support Truck
		erosion blanket	\$10,000.00	0.916	\$9,160.00	
		labor	\$2,760.00	0.916	\$2,528.16	3 - ATV
		Total	\$19,748.00	Subtotal	\$18,089.17	
		Restricted Use	Restricted Width Type 3 Roads	drainage control	incl.	4.1
water bars	incl.			4.1		
12"x12' culverts	incl.			4.1		ATV
spot stabilization	incl.			4.1		Support Truck
subtotal	\$4,375.00			4.1	17937.5	
slope revegetation				.55 ha only	\$6,594.00	
				Subtotal	\$24,531.50	
Road Upgrades	Drain + Leave Open Type 2 Roads	spot surfacing	\$4,687.50	4.657	\$21,829.69	Trail builder (hoe)
		turnpiking	incl.	4.657		Tracked Excavator
		revegetation	\$1,000.00	4.657	\$4,657.00	
						ATV
						Support Truck
				Subtotal	\$26,486.69	
	Improve Drainage Type 5 Roads	ditch relief	\$4,375.00	0.389	\$1,701.88	Tracked Excavator
		culverts	\$1,250.00	0.389	\$486.25	Tracked Excavator
		rock check dams &				
		sediment traps		incl.		ATV
		heavy treatment		incl.		Support Truck
		slope revegetation		0.25 ha only	\$3,187.00	
		fill slope				
		downslope spots				
		Subtotal	\$5,375.13			
SODA BUTTE CREEK TOTAL					\$74,482.48	

**NATURAL RESOURCE RESTORATION
WEST ROSEBUD CREEK ROAD COST ESTIMATE**

CATEGORY	ROAD TYPE	TASK	Cost/km	km	Cost	Equipment
Road Closures	Reclamation Type 1 Roads	Recontour	\$6,560.00	0.036	\$236.16	Tracked Excavator
		fertilizer	\$300.00	0.036	\$10.80	
		seed	\$128.00	0.036	\$4.61	Support Truck
		erosion blanket	\$10,000.00	0.036	\$360.00	
		labor	\$2,760.00	0.036	\$99.36	3 - ATV
		Total	\$19,748.00	Subtotal	\$710.93	
Restricted Use	Restricted Width Type 3 Roads	drainage control	incl.	0.036		Trail builder (hoe)
		water bars	incl.	0.036		
		12"x12' culverts	incl.	0.036		ATV
		spot stabilization	incl.	0.036		Support Truck
		subtotal	\$4,375.00	0.036	\$157.50	
		slope revegetation				
			Subtotal	\$157.50		
Road Upgrades	Drain + Leave Open Type 2 Roads	spot surfacing	\$4,687.50			Trail builder (hoe)
		turnpiking	incl.			Tracked Excavator
		revegetation	\$1,000.00			ATV
						Support Truck
				Subtotal	\$0.00	
	Improve Drainage Type 5 Roads	ditch relief	\$4,375.00	0		Tracked Excavator
		culverts	\$1,250.00			Tracked Excavator
		rock check dams &				
		sediment traps				ATV
		heavy treatment				Support Truck
		slope revegetation				
		fill slope				
downslope spots						
			Subtotal	0		
WEST ROSEBUD CREEK TOTAL					\$868.43	

NATURAL RESOURCE RESTORATION UNIT COST SUMMARY

Rip Roadbed	15-18 foot width		cost/hour		cost/km		Equipment	
	600 ft/hr						D-6 rippers	
	8.8 hours/ mile							
	5.5 hours/km		\$120.00		\$660.00			
Harrow Roadbed	15-18 foot width						D-6 harrow	
	1200 ft/hr							
	4.4 hours/ mile							
	2.75 hours/km		\$120.00		\$330.00			
Recontour Roadbed	30 foot width							
	2 \$/ft						Tracked Excavator 1 yd bucket	
	6.56 \$/m							
	6560 \$/km				\$6,560.00			
Fertilizer (Low Rate)	15:35:15 @ 50 # N/Acre							
	300 lbs/acre							
	750 lbs/ ha		\$20.00	per 100 lbs	\$82.50			
18 foot road width	0.55 ha/km							
Fertilizer (High Rate)	15:35:15 @ 100 # N/Acre							
	600 lbs/acre							
	1500 lbs/ha		\$20.00	per 100 lbs	\$300.00			
30 foot road width	1 ha/km							
Seed	slender wheatgrass, tufted hairgrass, alpine bluegrass							
	32 lbs/acre							
	12.8 lbs/ha							
18 foot road width	0.55 ha/km		\$10.00	lb	\$70.40			
30 foot road width	1 ha/km		\$10.00	lb	\$128.00			
Erosion Blankets								
18 foot road width obliterated only	none required							
30 foot road width	50 S-75		\$50.00		\$2,500.00		assumes 1/2 of roadway requires 30 foot width	
0.5 km covered	100 SC150		\$75.00		\$7,500.00		of 1/3 S-75, and 2/3 of SC-150	
				Subtotal	\$10,000.00			
Labor								
18 foot road width obliterated only	3 man days/km		\$100.00		\$300.00			
per diem	3 man days/km		\$80.00		\$240.00			
				Subtotal	\$540.00			
30 foot road width	3 man days/km		\$100.00	haul	\$300.00			
	3 ATV days		\$200.00		\$600.00			
full reclamation	3 man days/km		\$100.00	seed, fert	\$300.00			
	6 man days/km		\$100.00	blanket	\$600.00		2 people required	
per diem	12 man days/km		\$80.00		\$960.00			
				Subtotal	\$2,760.00			

road reclamation costs

APPENDIX D

DETAILED COST ESTIMATES

Miller Creek Response Action EE/CA

New World Mining District Response and Restoration Project

MILLER CREEK					
ENGINEER'S ESTIMATE - ALTERNATIVES					
New World Mining District Response and Restoration Project					
Miller Creek Response Action EECA					
ALTERNATIVE MC-1 - NO ACTION					
	Unit	Unit Cost	Quantity	Cost	Explanation
Monitoring	ls	\$37,318.20	1	\$37,318.20	Engineers Estimate
		Total Cost for Alternative:		\$37,318.20	
ALTERNATIVE MC-2 - In-Situ Reclamation of Waste Rock Dumps					
	Unit	Unit Cost	Quantity	Cost	Explanation
Clearing and Grubbing	ha	\$4,600.00	0.34	\$1,564.00	A B & J Mine Rec. Contractor Bid
Upgrade Access Roads	km	\$9,383.00	5.05	\$47,384.15	Basin/Cataract Creek Eng. Est.
Waste Spreading and Grading	m ³	\$3.82	3,150.0	\$12,033.00	McLaren Pit Eng. Estimate *2
Incorporate Lime in Upper 0.3 meters	ton	\$62.00	273.6	\$16,963.20	McLaren Pit Eng. Estimate
Drainage Channels	ls	\$1,000.00	27.0	\$27,000.00	Engineers Estimate
Erosion Control	ha	\$3,420.00	1.12	\$3,830.40	McLaren Pit Eng. Estimate x 2
Reclaim Roads	km	\$6,850.00	5.05	\$34,592.50	McLaren Pit Eng. Estimate
Revegetation	ha	\$31,278.00	1.12	\$35,031.36	McLaren Pit Eng. Estimate x 1.5
		SUBTOTAL		\$178,398.61	
		Mobilization (10%)		\$17,839.86	
		Contingency (12%)		\$21,407.83	
		TOTAL CONSTRUCTION		\$222,798.30	
Ancillary Actions:		Road Rehabilitation		\$558,193.18	
		Glengarry Wetland		\$97,400.00	
		Cumberland Debris Cleanup		\$11,965.00	
		TOTAL ANCILLARY		\$667,558.18	
		Eng. Eval. And Desgin (8%)		\$71,228.52	
		Const. Oversight (5%)		\$44,517.82	
		PRSC		\$54,759.17	
		Total Alternative Cost:		\$1,060,862	

NOTES
Used total area: 1.12 ha in Tbl 3-1 Assumed 30 % of total area
Includes all highlighted roads in Figure
Used total volume: 3150 cubic m in Table 3-1
(1.12 ha)(3000cu m / 1 ha)(1 ton / 1.4 cu m)(114 ton lime / 1000 ton material)
Assume \$1000 / dump, Count 27 dumps
Used total area: 1.12 ha in Tbl 3-1
Includes all highlighted roads in Figure
Used total area: 1.12 ha in Tbl 3-1

MILLER CREEK					
ENGINEER'S ESTIMATE - ALTERNATIVES					
New World Mining District Response and Restoration Project					
Miller Creek Response Action EECA					
ALTERNATIVE MC-3 - Total Removal of Waste and Transport to Repository SB-4B					
	Unit	Unit Cost	Quantity	Cost	Explanation
Waste Removal, Haul, and Place					
Clearing and Grubbing	ha	\$4,600.00	1.12	\$5,152.00	A B & J Mine Rec. Contractor Bid
Upgrade Access Roads	km	\$9,383.00	5.05	\$47,384.15	Basin/Cataract Creek Eng. Est.
Excavate, Load and Haul Waste	m ³ -km	\$2.76	24,222	\$66,852.72	Engineers Estimate
Regrade Removal Areas	ha	\$2,965.25	1.12	\$3,321.08	2000 Sel. Source Eng. Estimate
Revegetation of Removal Areas	ha	\$31,278.00	1.12	\$35,031.36	McLaren Pit Eng. Estimate x 1.5
Drainage Channels	ls	\$1,000.00	27	\$27,000.00	Engineers Estimate
Erosion Control	ha	\$3,420.00	1.12	\$3,830.40	McLaren Pit Eng. Estimate x 2
Reclaim Roads	km	\$6,850.00	5.05	\$34,592.50	McLaren Pit Eng. Estimate
Waste Spreading and Grading	m ³	\$3.82	4,242	\$16,204.44	McLaren Pit Eng. Estimate x 2
Repository	m ³	\$150.65	3,150.0	\$474,547.50	Selective Source Average Cost
		SUBTOTAL		\$713,916.15	
		Mobilization (10%)		\$71,391.62	
		Contingency (12%)		\$85,669.94	
		TOTAL CONSTRUCTION		\$870,977.70	
Ancillary Actions:		Road Rehabilitation		\$558,193.18	
		Glengarry Wetland		\$97,400.00	
		Cumberland Debris Cleanup		\$11,965.00	
		TOTAL ANCILLARY		\$667,558.18	
		Eng. Eval. And Desgin (8%)		\$123,082.87	
		Const. Oversight (5%)		\$76,926.79	
		PRSC		\$54,759.17	
		Total Alternative Cost		\$1,793,305	

MILLER CREEK					
ENGINEER'S ESTIMATE - PREFERRED ALTERNATIVE					
New World Mining District Response and Restoration Project					
Miller Creek Response Action EECA					
SELECTED SITES					
Selected site	Material Type	Volume (cubic m)	Area (ha)	Proposed Action	
MCSI-99-72, Miller Cr Dump One	waste	50	0.01	Alt. MC-2 - In-Situ Reclamation	
DCSI-99-91, Bull of the Woods Shaft/Dump	waste	20	0.01	Alt. MC-2 - In-Situ Reclamation	
MCSI-96-1, Miller Creek Dump Two	waste	220	0.10	Alt. MC-2 - In-Situ Reclamation	
Lower Miller Creek Dump 1	waste	30	0.05	Alt. MC-2 - In-Situ Reclamation	
Miller Creek Dump 4	waste	40	0.05	Alt. MC-2 - In-Situ Reclamation	
Total		360	0.22		
MCSI-96-2, Miller Cr Headwaters Dump One	waste	610	0.07	Alt. MC-3 - Total Removal	
ALTERNATIVE MC-2 - In-Situ Reclamation of Waste Rock Dumps					
	Unit	Unit Cost	Quantity	Cost	Explanation
Clearing and Grubbing	ha	\$4,600.00	0.07	\$303.60	A B & J Mine Rec. Contractor Bid
Upgrade Access Roads	km	\$9,383.00	2.88	\$27,023.04	Basin/Cataract Creek Eng. Est.
Waste Spreading and Grading	m ³	\$3.82	360.0	\$1,375.20	McLaren Pit Eng. Estimate *2
Incorporate Lime in Upper 0.3 meters	ton	\$62.00	53.7	\$3,329.40	McLaren Pit Eng. Estimate
Drainage Channels	ls	\$1,000.00	4.0	\$4,000.00	Engineers Estimate
Erosion Control	ha	\$3,420.00	0.22	\$752.40	McLaren Pit Eng. Estimate x 2
Reclaim Roads	km	\$6,850.00	2.88	\$19,728.00	McLaren Pit Eng. Estimate
Revegetation	ha	\$31,278.00	0.22	\$6,881.16	McLaren Pit Eng. Estimate x 1.5
		SUBTOTAL		\$63,392.80	
ALTERNATIVE MC-3 - Black Warrior and Little Daisy Dump Removals					
	Unit	Unit Cost	Quantity	Cost	Explanation
Waste Removal, Haul, and Place					
Clearing and Grubbing	ha	\$4,600.00	0.27	\$1,242.00	A B & J Mine Rec. Contractor Bid
Upgrade Access Roads	km	\$9,383.00	1.00	\$9,383.00	Basin/Cataract Creek Eng. Est.
Excavate, Load and Haul Waste	m ³ -km	\$2.76	12,498	\$34,494.48	Engineers Estimate
Regrade Removal Areas	ha	\$2,965.25	0.27	\$800.62	2000 Sel. Source Eng. Estimate
Revegetation of Removal Areas	ha	\$31,278.00	0.27	\$8,445.06	McLaren Pit Eng. Estimate x 1.5
Drainage Channels	ls	\$2,000.00	1	\$2,000.00	Engineers Estimate
Erosion Control	ha	\$3,420.00	0.27	\$923.40	McLaren Pit Eng. Estimate x 2
Reclaim Roads	km	\$6,850.00	1.00	\$6,850.00	McLaren Pit Eng. Estimate
Waste Spreading and Grading	m ³	\$3.82	1,806	\$6,898.92	McLaren Pit Eng. Estimate x 2
Repository	m ³	\$150.65	1,290	\$194,338.50	Selective Source Average Cost
		SUBTOTAL		\$265,375.98	
		TOTAL MC-2 & MC-3		\$328,768.78	
		Mobilization (10%)		\$32,876.88	
		Contingency (12%)		\$39,452.25	
		TOTAL CONSTRUCTION		\$401,097.91	
Ancillary Actions:		Road Rehabilitation		\$558,193.18	
		Glengarry Wetland		\$97,400.00	
		Cumberland Debris Cleanup		\$11,965.00	
		TOTAL ANCILLARY		\$667,558.18	
		Eng. Eval. And Desgin (8%)		\$85,492.49	
		Const. Oversight (5%)		\$53,432.80	
		PRSC		\$14,237.38	
		Total Preferred Alternative Cost:		\$1,221,819	